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**Understanding critical thinking in American higher education: From  
Chinese international and domestic STEM students' perspectives**

by

**Lu Yan**

A dissertation submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Education

Program of Study Committee:

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The student author, whose presentation of the scholarship herein was approved by the program of study committee, is solely responsible for the content of this dissertation. The Graduate College will ensure this dissertation is globally accessible and will not permit alterations after a degree is conferred.

Iowa State University

Ames, Iowa

2018

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**DEDICATION**

To my parents 阎竹良(Yan Zhu Liang) and 王林风(Wang Lin Feng) who have been a constant source of support and encouragement during the challenges of graduate school and life. I am truly thankful and fortunate for having you in my life. This work is also dedicated to my baby niece, 米米(Mimi)—a bundle of pure joy, without whom this dissertation would have been completed one year earlier.

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## **ABSTRACT**

This qualitative dissertation sought to understand how twenty-five junior and senior STEM major students perceive and experience critical thinking. It utilized a transcendental phenomenology approach and analyses to answer the following research questions: How do Chinese international and domestic junior and senior STEM students perceive and describe critical thinking? Do the two groups both believe critical thinking has an important impact on their education and life in general? What suggestions do the two groups have for their instructors to facilitate their critical thinking comprehension and application? The research employed a transcendental phenomenology approach that enabled me, as the researcher, to be more reflective of my own prejudgment and pre-knowing towards the study and participants, and to explore how students themselves experience the concept of critical thinking to gain a clear understanding of their curriculum and learning. The results showed that they understood and experienced critical thinking as a way of thinking, problem solving, a process, and also a confusing concept. All participants thought critical thinking was important for their education and career, but less important for their everyday lives. Participants valued their authentic research and learning experiences, interactions with their instructors and meaningful small group activities from their curriculum.

**Keywords:** Critical thinking, STEM student learning, Transcendental Phenomenology

## **CHAPTER 1. INTRODUCTION**

Critical thinking is an essential goal of American higher education. The Association of American Colleges (1985), National Institute of Education (1984), and the National Education Goals Panel (1991) have all stated the importance of developing college students' critical thinking. The National Education Goals Panel in 1991 further established a goal to substantially increase "the proportion of college graduates who can demonstrate an advanced ability to think critically, communicate effectively, and solve problems" (p. 62). Critical thinking is involved in every aspect of our school subjects and everyday lives. In particular, teaching critical thinking has been emphasized in STEM education (Bissell & Lemons, 2006). However, few students understand and use critical thinking for acquiring knowledge in their schooling, and "they gain little knowledge or insight" in thinking critically (Paul, 1990, p.1). Chinese international students are the largest international student population studying in the US (Open Doors Data, 2017). Some concluded that Chinese students lack critical thinking because they scored lower than their Western peers in critical thinking tests (Tiwari, Avery & Lai, 2003; Huang, 2008). Others asserted that they were only unfamiliar with the Western style of critical thinking (Durkin, 2008; Tian & Low, 2011). In this chapter, I discuss the definition of critical thinking, college student cognitive development models, teaching critical thinking and international students in the following sections.

### **Critical Thinking Definition**

While scholars define critical thinking in different ways, they have agreed that critical thinking essentially is a mental activity that does not concentrate on fault finding as the word 'critical' might imply, but rather on seeking the truth and establishing what to

do and what to believe (Chiu 2009, p. 43). Scriven and Paul (1987) specifically suggested two common components of critical thinking: 1) a set of skills, and 2) the willingness or habit or “critical spirit” as noted by Siegel (1992). The set of skills includes six core skills that were identified by critical thinking experts in the American Philosophical Association report (APA; Facione, 1990): analysis, evaluation, explanation, interpretation, inference, and self-reflection or self-regulation. These core skills have also been endorsed by other scholars in the extant literature (e.g., Chaffee, 2014; Jones, Hoffman, Moore, Ratcliff, Tibbetts, & Click, 1995). In addition to regularly exercising the core skills, it is believed that well-cultivated critical thinkers are also more willing and disposed to engage in critical thinking. For the critical thinkers to develop appropriate critical thinking habits or dispositions, Ennis (2011, p.15) said that ideal critical thinkers: (a) care that their beliefs be true, and that their decisions be justified (e.g., be open-minded and willing to take others’ opinions seriously), and (b) care to understand and present a position honestly and clearly (e.g., be willing to be reflective about personal perspectives), as well as (c) care about every person (i.e., consider others’ feelings and welfare). In addition to the skills and dispositions, scholars also believe that critical thinking is closely related to cognitive and intellectual development theories. In the following section, I discuss two of these theories.

### **Models of College Student Cognitive and Intellectual Development**

College students are believed to undergo several cognitive and intellectual development stages until they eventually develop a habit of analytical and critical thinking (e.g., Perry’s Scheme and Reflective Judgment Theory; King & Kitchener, 1994;

Perry, 1970; Trosset, 1998). I briefly introduce the two models here; a more in-depth discussion is provided in Chapter 2.

### **The Perry Scheme**

Perry (1970) believed that students transform intellectually through nine positions, or stages, in their learning development. Through these nine positions, students' perceptions of knowledge shift gradually from a basic Dualistic perspective (positions 1, 2 & 3), to the Realizing of Relativism stage (positions 3, 4 & 5), and eventually to the Evolving of Commitments (positions 7, 8 & 9). For example, in the dualism stage, students are faithful to authorities (i.e., teachers) and do not question the information they are learning or the grades they receive. In the relativism stage, students appreciate and anticipate that all knowledge and values are "accepted" and relative in our world, and that some answers can be unknown. In the Commitment stage, they start to live a life with open-mindedness and flexibility to this relative and contextual world.

### **Reflective Judgment Theory (RJT)**

Similar to the Perry Scheme (1970), Reflective Judgment Theory (RTJ; King & Kitchener, 1994) also asserts that students go through different intellectual stages to eventually get to the reflective and critical mind. It suggests seven steps, which are categorized into three levels that students go through: pre-reflective thinking (steps 1-3), quasi-reflective thinking (steps 4-5) and reflective thinking (steps 6-7). In the pre-reflective stages, students tend to see knowledge as absolute. In the quasi-reflective thinking stages, students recognize that knowledge is subjective; and in the reflective thinking stages, students understand that knowledge is contextual.

### **Teaching Critical Thinking**

Critical thinking is a product of Western culture. The history of critical thinking can be traced back to the ancient Greek philosophers like Socrates, Plato, and Aristotle who believed that knowledge and insight should be based on sound evidence through a method of critical and logical probing and questioning, instead of depending on authorities. Therefore, in American classrooms teachers tend to use questions to lead and facilitate students' learning and encourage students to use reasoning and questioning to clarify knowledge (DeAngelo, Hurtado, Pryor, Kelly, Santos, & Korn, 2009; Durkin, 2008; Phuong-Mai, Terlouw & Pilot, 2005). That is, critical thinking is mutually expected between American students and teachers in classrooms. As a high order of human mental process and activity, however, teaching critical thinking in classrooms is not an easy task.

Although many scholars have agreed upon a set of core skills and dispositions of critical thinking that (Chaffee, 2014; APA, 1990; Scriven & Paul, 1987; Siegel, 1997), critical thinking cannot be taught by simply asking students to memorize the list. Instead, educators are encouraged to have a systematic way to explain and execute classroom activities that involve with critical thinking skills and dispositions (APA, 1990; Duron, Limbach & Waugh, 2006). For example, critical thinking teaching strategies may include (a) introducing new knowledge to students based on what is already known, b) explicitly describing learning goals to the class and integrating them into students' learning process, and c) clearly exposing and analyzing the judging and reflection process on any statements/opinions to students (APA, 1990; Duron et al., 2006).

As a complex concept, teaching and learning critical thinking in a second language (L2) is even more complicated (Lantolf, 2006; Mroz, 2014). As L2 learners, Chinese international students may experience extra language and cognitive difficulties as they learn to think and write critically (Ramanathan & Kaplan, 1996b). L2 students' intellectual development, especially critical thinking development, is said to depend on their English language proficiency (Boroditsky, 2001) and the surrounding environments in the target culture /language (i.e., cultural artifacts, activities and concepts) (Lantolf, 2006; Lantolf & Thorne, 2006; Thorne, 2003, 2005). That is, Chinese international students' English language proficiency, as well as academic and cultural adjustment issues may limit their cognitive development in thinking critically (Lantolf, 2006; Mroz, 2014; Ramanathan & Kaplan, 1996a, 1996b). International students are an important asset in 21<sup>st</sup> century global education. In the following section, the benefits that they have brought in to the U.S. campuses and their unique challenges are discussed.

### **International Students in the US**

International students on US campuses have provided significant economic growth for universities and boosted multicultural competencies among domestic students. In the 2016-2017 academic year, for example, more than a million international students enrolled at U.S. universities and colleges, which created more than 373,000 jobs and contributed \$39.4 billion to the U.S. economy in 2016 (Open Doors Data, 2017). More importantly, the presence of international students on campuses adds to the diversity of the American college student body, promotes domestic students' cultural awareness, and helps students' overall higher order thinking including critical thinking abilities (Gurin, Dey, Hurtado, & Gurin, 2002; Luo & Jamieson-Drake, 2013; Zhao, Kuh, & Carini, 2005).

## **Chinese International Students in the US**

According to the Open Doors Data (2017) report, one of every three international students is from Mainland China. Studies (Perkins, 1977; Lin, 1998; Yan & Berliner, 2009) showed that international students who are from Third-World and Eastern countries (e.g., mainland China) generally experience greater academic stress and adjustment issues when they study in a Western country (e.g., U.S., Australia, England, Canada). For example, Chinese students are less academically prepared (Perkins, 1977) and easily get confused and frustrated when they are asked to learn independently (Yan & Berliner, 2009). For critical thinking, some studies showed that Chinese students might have inadequate critical thinking skills and dispositions (Ten Dam & Volman, 2004; Ip, Lee, Lee, Chou, Wootton & Chang, 2000; Ku & Ho, 2010; Thayer-Bacon, 2000); other studies suggested that Chinese students might be just unfamiliar with Western-style critical thinking skills, which often leads people from the West to recognize them as poor critical thinkers (Cheng, 2000; Durkin, 2008).

Confucianism Chinese culture is very different from Western culture, which is very familiar with elements of critical thinking in classrooms as mentioned earlier. For example, Chinese culture values social hierarchy and group harmony, which encourage people to respect to authorities and not question any pre-defined social order (Fan, 1995; Zhao, 2007). In Chinese classrooms, therefore, teachers are seen as authorities and expect students to memorize and recite structured ideas rather than debating and self-expressing (Hofstede & Bond, 1988; Lee, Lee, Makara, Fishman & Hong, 2014). Studies not only suggested Chinese students have low critical thinking, but also attributed the reasons to Confucianism culture (Atkinson, 1997; Ten Dam & Volman, 2004; Paul, 1994). In other



words, in Chinese classrooms critical thinking often times is not taught, encouraged or appreciated as much as it is in American classrooms.

### **Problem Statement**

Previous research studies have examined students' performance on critical thinking tests (e.g., California Critical Thinking Skills Tests, California Critical Thinking Disposition Inventory), however, little/no research has examined how students themselves qualitatively experience and understand this concept. Moreover, while all disciplines in higher education encourage critical thinking, STEM fields recently have put special emphasis on teaching students to think critically (Bissell & Lemons, 2006). STEM is becoming a popular field for both domestic students and international students. In the U.S., STEM majors are the most popular among Chinese international students (Ang, 2015). Therefore, it is imperative for researchers, educators, and administrators to understand how STEM students in particular experience and understand critical thinking. This knowledge can also inform higher education practitioners and researchers about the perspectives of STEM students regarding critical thinking.

### **Research Questions**

To address this purpose as mentioned above, the present study examines the following central question: How do Chinese international and domestic junior and senior STEM students experience and understand critical thinking? I also investigated two subquestions: (1) Do the two groups both believe critical thinking has an important impact on their education and life in general? (2) What suggestions do the two groups have for their instructors to facilitate their critical thinking comprehension and application?

### **Significance of the Study**

The study aims to fill a gap in understanding how STEM undergraduates experience and understand critical thinking. This study is different from previous research that focused on examining students' performance in critical thinking tests. As the ones who receive the benefits of thinking critically in education, it is imperative to clearly hear from students themselves about their experiences and understanding of critical thinking.

First, the findings of the present study allow researchers and educators to understand STEM students' own experiences with critical thinking, which ultimately can provide more support to students' learning. In addition, the results can also highlight the gap between professors' expectations and students' own interpretations of critical thinking requirements in their studies. Incoming college students can be explicitly informed and prepared on the frequency, importance, requirements and even procedures of thinking critically in their studies.

Second, findings of the study allow Chinese international students' critical thinking to be better understood and interpreted through their own words, which can also be used to develop strategies to educate them more successfully on the US campuses. For example, instead of mistakenly perceiving Chinese students' quietness and agreeableness in lectures as a lack of critical thinking, instructors may initiate critical thinking through different approaches (e.g., research projects, more interactions with the students after lectures).

Finally, the research may add new perspectives to the current literature about critical thinking and teaching critical thinking. Previous research has measured students'

performance in critical thinking tests, but the current study focuses on hearing from participants/students themselves on their critical thinking experiences. The study highlights what the participants think they need and their suggestions for improving critical thinking experiences in their education. Their suggestions could make the critical thinking teaching strategies discussed in the existing literature more comprehensible and well rounded.

### **Research Design Overview**

The present study is an extension of a qualitative pilot study that examined how five female Chinese international first year students perceived critical thinking through the lens of their academic and cultural adjustments in the U.S. (Yan, 2016). The results showed their unfamiliarity and reluctance with critical thinking was mainly because of the challenges from learning a new language, adapting to this new culture, and academia. I chose a phenomenology approach to answer my research questions; the rationale for choosing this approach is discussed in detail in Chapter Two. The participants for the present study were a group of Chinese international students and a group of domestic students. They were all STEM junior or senior students enrolled at a large Midwestern university. Chinese participants were delimited to those who had not had any K-12 education in an English speaking country (e.g., England, Australia, U.S.). In depth and one on one interviews were conducted and interview questions were used to explore participants' experience and perceptions of critical thinking. A more detailed description of the methods is presented in Chapter 3. In the next chapter—Chapter 2, the extant literature related to the study is discussed including the nature of critical thinking, the

importance of critical thinking, teaching critical thinking and cultural differences in critical thinking.

## CHAPTER 2. LITERATURE REVIEW

The purpose of this study is to explore how two groups of students—Chinese international and domestic STEM students—perceive and describe their experience of critical thinking. Scholars believe that few students understand and use critical thinking for acquiring knowledge in their schooling (Paul, 1990). As a result, “they gain little knowledge or insight...[and] their adaptability, their capacity to learn on the job and in their personal and civic lives, is severely limited” (p.1). Specifically, Chinese students’ critical thinking has been debated in the literature as to whether they are better or worse in critical thinking compared to their Western peers (e.g., peers from U.S., Australia, UK, Russia). Some concluded that Chinese students scored lower than their Western peers (Huang, 2008; Tiwari et al., 2003), while others asserted that they were only unfamiliar with the Western style of critical thinking (Durkin, 2008; Tian & Low, 2011).

To identify literature relevant to the study, I collected references from books, dissertations, internet sources, and computerized resources from ERIC, JSTOR, ProQuest, Google Scholar, using key words like: *critical thinking*, *critical thinking skills*, *critical thinking dispositions*, *Chinese international college students*, *Chinese STEM college students*, *college student development*, and *college student success*.

The literature review provides a theoretical background and framework for answering the central research question: How do Chinese international and domestic junior and senior STEM students perceive and describe critical thinking? and two subquestions: (1) Do the two groups both believe critical thinking has an important impact on their education and life in general? (2) What suggestions do the two groups

have for their instructors to facilitate their critical thinking comprehension and application?

In the following sections, I review the literature on: (a) the nature of critical thinking, (b) the importance of critical thinking, c) teaching critical thinking, d) language and critical thinking, and e) culture differences on critical thinking. This literature is used as the conceptual framework for my study.

### **The Nature of Critical Thinking**

Scholarly research generally categorizes three approaches to the explanation of the nature of critical thinking: those related to *state* perspectives (i.e., abilities and skills), those related to *trait* perspectives (i.e., inherent dispositions), and those related to *emergent* perspectives (i.e., cognitive development) (Halonen, 1995). *State* approaches focus on critical thinking as an act of behavior. This perspective emphasizes the demonstration of critical thinking and believes that critical thinking is a multidimensional ability and needs to be enhanced through formal training. *Trait* approaches emphasize critical thinking as inherent intellectual ability and characteristic that motivates people to think critically; eventually critical thinking becomes habitual. *Emergent* approaches consider critical thinking as an aspect in cognitive development. This perspective believes that critical thinking development is systematic and will emerge naturally over time without formal instruction of skills (Halonen, 1995).

In the following sections, the three approaches will be discussed in detail. The *state* (abilities and skills) and *trait* (dispositions) approaches will be discussed together because they usually appear together in critical thinking literature, and then *emergent* (cognitive/intellectual development) approach will be discussed.

## Perspectives Related to Abilities and Dispositions

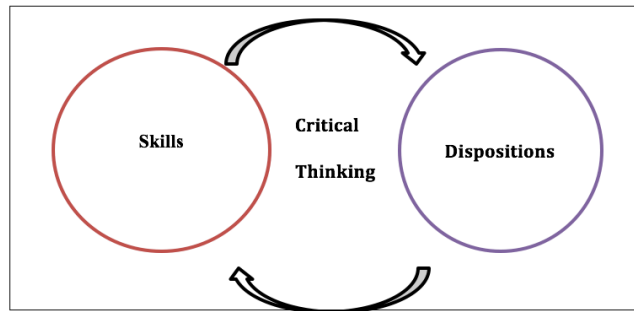
Critical thinking is a rigorous process of evaluating and accessing information while making purposeful and self-regulatory judgment (American Philosophical Association, 1990; Paul & Elder, 2006; Scriven & Paul, 1987). According to the work from the Delphi report (APA, 1990), Facione and Facione (1992), Facione (2000; 2015), Paul (1990) and Siegel (1997), critical thinking includes two involving factors: an ability/skill dimension, and a disposition dimension. The ability dimension includes six core skills and the disposition dimension—people’s consistent internal motivation to act toward critical thinking—has seven character attributes. The following table 1 illustrates the skills and dispositions (APA, 1990; Facione & Facione, 1992; Facione, 2000):

Table 1: *Two Dimensions of Critical Thinking*

<b>Perspectives related to Abilities</b> 6 Core Skills	<b>Perspectives related to Dispositions</b> 7 Core Dispositions
Analysis	Analyticity
Evaluation	Critical thinking self-confidence
Explanation	Inquisitiveness
Interpretation	Maturity of judgment
Inference	Open-mindedness
Self-judgment	Systematicity
	Truth-seeking

The experts who participated in the Delphi report (APA, 1990) believed that, through practice, critical thinking skills can be developed like other natural abilities. But Facione (2000, p. 62) warned that “we should take care not to confuse the component skills with the activity itself,” because the activity also involves the disposition dimension. That is, although skills and dispositions are two different things, they mutually reinforce the process and activity of thinking critically. For example, a strong overall disposition

toward critical thinking is integral to insuring the use of critical thinking skills and would impel an individual to achieve mastery over critical thinking skills (Facione, 2000). The following figure 1 shows the correlation between the dimension of skills and the dimension of dispositions:



*Figure 1.* Correlation between the skills and the dispositions of critical thinking

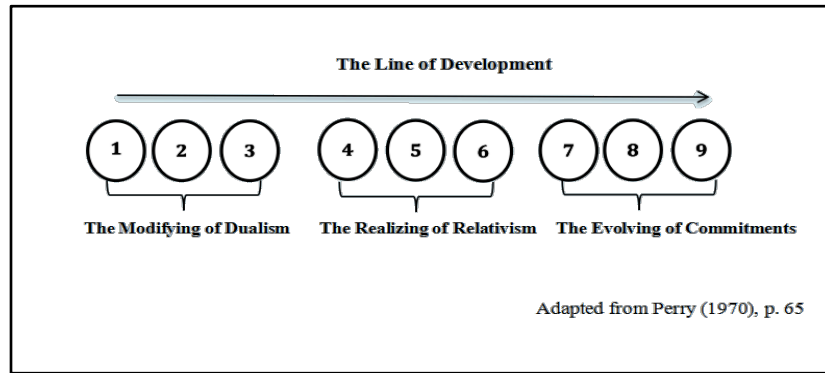
### **Perspectives related to Cognitive/Intellectual Development**

Perry's (1970) Scheme and the Reflective Judgment Model (RJM; King & Kitchener, 1994) are two intellectual and ethical development frameworks that are widely used to describe cognitive development in college students. They provide a foundational framework for understanding critical thinking from the perspective of cognitive development.

**The Perry Scheme.** Scholars suggest that college students undergo several cognitive and intellectual development stages to eventually develop a habit of analytical and critical thinking. Perry's (1970) Scheme is a fundamental theory in the cognitive development literature. It suggests that students come to college with different levels of critical thinking skills and dispositions. Perry studied 109 Harvard undergraduate students' assumptions of knowledge and learning for four years and developed a scheme of how students cognitively progressed during their college years. Figure 2, adapted from



Perry's Scheme (1970), shows the nine positions and stages—the modifying of dualism, the realizing of relativism and the evolving of commitments:



*Figure 2.* Nine positions in Perry's Scheme

Perry (1970) suggested nine positions that students transform through during their learning development. He grouped these nine positions into three stages as shown in Figure 2 above: "The Modifying of Dualism" (position 1, 2, & 3), "The Realizing of Relativism" (position 4, 5, & 6), and "The Evolving of Commitments" (position 7, 8, & 9) (p. 65). In the following paragraphs I briefly explain the nine transitioning positions.

In position 1, typically students believe that "any proposition or act must be either right or wrong. It cannot be better or worse" (p. 71), and morality should consist of committing to memory, working hard, and having correct answers and procedures as assigned by Authority (p. 66). Students do not doubt what they are being told, but wholeheartedly follow their instructor's directions. In Position 2, students still are loyally "adherent to Authority" (p. 87) but may start feeling the value of independence and doubt. In position 3, although students still see knowledge and values as coming from Authority, they also start realizing uncertainty and complexity. For example, although Authority [i.e., the instructor or professor] still grades a student's answer...he [the student] will now

listen with more open ears to what his instructor says they are up to” (p. 102). In these first three positions, students are faithful to Authority and hold an absolutistic right-wrong outlook with a simple dualistic perspective. That is, they do not believe they can determine a right answer by themselves (Lorenzen, 2001). For example, students in Trosset’s (1998) study felt discomfort about being challenged by others (maybe in position 1 or 2) but overcame that epistemological belief when they progressed into a higher position (e.g., position 5 or 6).

In position 4, instead of simple right-wrong dualism, students see the existence of multiplicity. For example, they appreciate the fact that some answers can be unknown and everyone has a right to his own opinion (p. 107). Under the Authority’s guidance, they discover that “independent-like thought [instead of ‘correct answers’] gets a good grade” (p. 113). In position 5, “Authority becomes authority” (p. 135), with whom students now have a horizontal instead of a vertical relationship. Students perceive all knowledge and values as “accepted” and relative in our world. They no longer just believe in what they are told without any doubt. This position is a turning point where students move from perceiving knowledge and values as a basic dualistic perspective to a relativism perspective and eventually are willing to make commitments to new experiences flexibly and openly (Perry, 1970). In position 6, students anticipate and presuppose human limits and make *Commitments* to this relativistic world, instead of an either right or wrong dualistic worldview. They uphold living an examined life. In this stage, in other words, students believe that everything is possible and knowledge is never absolute. Perry (1970) suggested that most universities do not get their students past this relativism during their undergraduate experience.

In positions 7, 8, and 9, students explore and practice their personal *Commitments* through their own actual experiences, with open-mindedness and flexibility. These last three positions “are beyond most high school students and many undergraduate college students” (Lorenzen, 2001, p. 153). *Commitments* define their identity and values in this contextual and relativistic world. Students in these positions generally represent a higher level of intellectual and cognitive development.

Perry’s scheme reflects “a difficult journey toward more complex forms of thought about the world, one’s discipline/area of study, and one’s self” (Moore, 2001, p. 19). The journey is sometimes repeated, and one can be at different positions at the same time with respect to different subjects.

**The Reflective Judgment Model (RJM).** Built on Dewey’s (1916, 1933) concept of reflection and informed by Perry’s Scheme (1970), the Reflective Judgment Model (RJM) was developed by King and Kitchener in 1994, as an adaptation of Piaget’s (1972) theory of cognitive development. It contains epistemological and metaphysical assumptions about the ways in which people use evidence and justify beliefs (McMillan, 1987).

After interviewing over seventeen hundred students for ten years about their reflective thinking and how it develops, King and Kitchener (1994) described seven steps that a person goes through in his or her reflective thinking development: (a) knowledge is assumed to be absolute; (b) knowledge is assumed to be absolute but not immediately available; (c) knowledge is assumed to be temporarily uncertain; (d) knowledge is uncertain; (e) knowledge is contextual and subjective; (f) knowledge is constructed into individual conclusions; and (g) knowledge is the outcome of a process of reasonable

inquiry (King & Kitchener, 1994, p. 14-15). These seven steps are then further categorized into three levels: pre-reflective thinking (step 1-3), quasi-reflective thinking (step 4-5) and reflective thinking (step 6-7).

Instead of proposing a “simple stage” theory such as Kohlberg (1969) suggested, RJM endorses Rest’s (1979) *complex stage theory*, which asserts that a person’s reflective thinking does not evolve “in a lock-step, one-stage-at-a-time fashion” (p. 9) but rather involves a mixture of steps. That is, similar to what Perry (1970) believed about repeated and different positions at the same time on different subjects, RJM asserts that reflective thinking development is like uneven and overlapping “waves across a mixture of stages, where the peak of a wave is the most commonly used set of assumptions” (King, Kitchener & Wood, 1994, p. 140).

RJM also considers reflective thinking development to be sequential and increasing across steps over time. For example, a high school junior student in 1977 increased his Reflective Judgment Interview (RJI) score from 2.67 in step 3 in 1977 to 5.84 in step 6 in 1987 (King & Kitchen, 1994, p. 277). In addition, RJM increases as educational levels go up. That is, scores on the RJM reflect increases across more highly educated populations: high school ( $M = 3.2$ ), first year in college ( $M = 3.63$ ), senior year in college ( $M = 3.99$ ), early graduate study ( $M=4.62$ ) and advanced doctoral study ( $M=5.27$ ) (King & Kitchener, 1994, pp. 279-283). Although RJM is not synonymous with critical thinking (King & Kitchener, 1994), RJM can greatly foster people’s epistemic cognition, which is the foundation of critical thinking. In other words, RJM is a necessary framework for critical thinking (King & Kitchener, 1994).

After reviewing Perry's Scheme (1970) and RJM (1994), Perry's Scheme (1970) serves as an outline for understanding students' cognitive and intellectual developments. It "suggests that critical thinking is a developmental process with recognizable stages and that each stage involves how a person views knowledge and learning" (Thoma, 1993, p.128). Therefore, this study will use the Perry Scheme (1970) as the cognitive perspective for understanding critical thinking.

All in all, the three perspectives—*state*, *trait* and *emergent* (Halonen, 1995)—together contribute to a more complete understanding of critical thinking. Because the nature of critical thinking is multifaceted and complicated, the current study uses all the three perspectives as part of the conceptual framework to better explore how the participants understand and experience critical thinking.

### **The Importance of Critical Thinking**

As one of the most profound American educational reformers, John Dewey (1916, 1933) first proposed "good habits of thinking" as a basic principle around which schools should organize curriculum (1916, p. 163). Critical thinking is not only a liberating force in education and a powerful resource in one's personal life, but also is the basis of a rational and democratic society (APA, 1990).

Critical thinking is crucial in education. In fact, learning critical thinking skills has been emphasized for decades in K-12 and college education (Marshall & Tucker, 1992). Faculty in higher education have endorsed critical thinking as one the most important goals of undergraduate education (DeAngelo et al., 2009; MacKnight, 2000). Critical thinking is also highly valued in workplace, and more appreciated than a job applicant's undergraduate major. In a national survey, 93% of employers wanted

candidates to demonstrate capacity to think critically, but indicated that it was among the areas in which higher education should place greater emphasis (Association of American Colleges and Universities, 2013). Moreover, critical thinking is highly regarded in a rational and democratic society. In the information age, without significant life experiences, young people may be vulnerable to shallow information appeal (Kasten, 2012) instead of valid and credible analysis, and could make decisions that cause harm to the democratic society as a whole.

### **Critical Thinking in STEM Fields**

Science and technology development both involve the process of generating and systematically testing hypotheses, in which thinking intelligently and critically is a foundation. Although STEM education recognizes critical thinking as a core element, it has not been taught in an organized and systematic way, nor has it been promoted and encouraged enough (Miri, Ben-Chaim & Zoller, 2007; Tsui, 1998, 2002). Instead, most college STEM courses, especially introductory courses, have focused too much on students' memorization of content knowledge (Gasiewski, Eagan, Garcia, Hurtado & Chang, 2012). Students are asked to simply follow instructions like a cookbook without thinking and learning adequately (Martin-Hansen, 2002). However, instead of simply following instructions and memorizing facts, STEM students should be encouraged to explore the nature of science and scientific ideas rather than only scientific facts, and to frequently reflect on their own actions and interpretations through open dialogues and discussions (Garrison, 1991). Other researchers suggested that STEM students should learn and do real science in authentic inquiry related research, case studies and even lectures (Quitadamo, Faiola, Johnson & Kurtz, 2008; Rowe, Gillespie, Harris, Koether,

Shannon & Rose, 2015). Through a rigorous scientific research process, STEM students will learn to focus more on evidence and logic, and also “learn the values and beliefs of science without a particular viewpoint being imposed on them. This in turn may encourage greater openness to learning and thinking skills” (Quitadamo et al. 2008, p. 334).

STEM education is considered a key portion of the public education agenda in U.S. and Chinese culture. It has attracted many international Chinese students to study in the U.S. While it is a popular field to choose, Chinese international STEM students may struggle more than their American peers in general. In the next section, I first discuss how critical thinking is taught and then address one specific difficulty that Chinese international STEM students may face: understanding critical thinking as ESL students.

### **Teaching Critical Thinking**

Teaching critical thinking involves combining the two key components (abilities and dispositions) by building critical thinking skills and nurturing appropriate corresponding dispositions. However, critical thinking experts from the Delphi report (APA, 1990) warned that educators should avoid delivering these skills and dispositions as a body of knowledge to students, just like one more school subject. Instead, good critical thinking teachers (p. 31):

- Use explicit instruction in applying critical thinking skills (i.e., describing and explaining how and why the skills are applied in a particular situation).  
Instruction can be simple first but become gradually more complex;
- Purposefully expose students to the teachable situations/moments where reasoning and judgment are required and provide students with immediate

constructive feedback;

- Motivate learners to eventually apply critical thinking in real world situations independently.

While these suggestions are easily understood, they are not as easily applied in practice without further details. In order to efficiently implement these teaching recommendations, therefore, Duron et al. (2006) suggested a detailed five-step framework in classrooms:

In step 1, teachers explicitly determine and identify key learning objectives for the class. In a lesson plan, for example, teachers can purposefully add critical thinking focused objectives and activities. In step 2, teachers should make questioning and reasoning the goal of their teaching. Through asking purposeful and appropriate questions (e.g., “why” questions) and supporting students with explanations and justified answers, the interactions between teachers-students and students-students can greatly stimulate students’ higher order thinking development. In step 3, teachers need to choose appropriate activities to encourage active learning and foster students’ critical thinking. In step 4, teachers carefully monitor classroom activities, track students’ performance, and improve their learning. Duron et al. (2006) recommended a 2-minute paper task—asking students to identify the most important point learned. Teachers can review the comments and use them in future classes to emphasize identified issues. In step 5, teachers provide thoughtful and purposeful feedback. Instead of only giving grades, teachers support students’ learning by providing informational and constructive feedback. Through this five-step framework, teachers can actively help students learn critical thinking skills while at the same time nurturing their critical thinking dispositions/habits.



Although in this study I did not interview instructors on their perspectives about teaching critical thinking, I did ask all my participants about what they thought helped and hindered their critical thinking development, and how they thought their undergraduate curriculum addressed critical thinking. Their responses reflect these teaching strategies and will be discussed in detail in Chapter Four. In the following section, I discuss how second language students learn to think critically.

### **Language and Thought, and Critical Thinking in a Second Language (L2)**

Language development and cognition are closely related. Language helps us think and “serves as a cornerstone for human cognition” (Berwick, Friederici, Chomsky & Bolhuis, 2013, p. 89). Scholars of the linguistic relativity hypothesis (Sapir, 1921, 1951; Whorf & Carroll, 1956) share this opinion and believe that language, especially native/first language, has an important influence on a person’s ways of thinking and seeing reality. For example, Boroditsky (2001) studied how Chinese Mandarin and English speakers thought differently about the concept of time—English speakers predominantly talk about time as if it were horizontal while Mandarin speakers commonly describe time as vertical. He concluded that one’s native language can be a powerful tool for shaping abstract thought...[and] may “play the most important role in shaping how speakers think” (p. 20). In addition to language, scholars of sociocultural theory (Vygotsky & Kozulin, 1962; Lantolf, 2006; Ratner, 2002; Thorne, 2003, 2005) also believe that interactions within social and material environments including conditions found in instructional settings greatly promote people’s cognitive activity development.

Thinking critically in L2 is even more intricate than in one’s first language (L1)

(Lantolf, 2006; Mroz, 2014). In addition to learning the new language, L2 learners often are unfamiliar with and have fewer interactions within the social and material environments in L2 environments, compared to their L1 peers. Therefore, L2 learners may have apparent cognitive disadvantages that would negatively affect their critical thinking performance (Mackee, Rispoli, McDanie, & Garret, as cited in Floyd, 2011).

In the current study, I chose 25 junior and senior participants with the assumption that, after two or three years studying in this Midwest university, they have become familiar with and have had interactions within the social, cultural, material, and academic environments of this university, including having had critical thinking activities in their instructional settings.

### **Cultural Differences in Critical Thinking**

The culture in which a learner grows up is a major factor contributing to his or her development of critical thinking (Grosser & Lamboard, 2008). Atkinson (1997) believed that “critical thinking is cultural thinking” and therefore is only “discoverable...to those brought up in a cultural milieu in which it operates... as a socially valued norm” (p. 89). Ten Dam and Volman (2004) noted “to be critical seems to be part of our Western culture” (p. 360). Culture is one of the most important reasons explaining Asian L2 students’ greater challenges to think critically relative to their Western peers (Bond, 1996; Hofstede, 2001; Johnson, 1992; Egege & Kutieleh, 2004). Western culture is characterized as low power distance (e.g., people readily question authority), high individuality (e.g., people emphasize individual rights), and low uncertainty avoidance (e.g., people encourage sharing of ideas and opinions and allow freedom of expression) (Hofstede, 2001). Students growing up in this culture are often familiar with critical

thinking including “rigorous debate, aggressive search for truth and a discerning of error, bias and contradiction” (Paul, 1994; Ennis, as cited in Durkin, 2008, p. 17), open discussion, wrestling debate with logic (Durkin, 2008; Walkner & Finney 1999), making one’s own choices, and respecting the choices and opinions of others (Ten Dam & Volman, 2004).

On the other hand, Confucianism Chinese culture is almost the opposite of the Western culture described above. It is characterized as high-power distance (e.g., people are expected to display respect for those of higher status and obedience to the authority), low individuality, and high uncertainty avoidance (e.g., students expect their teachers to be experts who have all the answers) (Hofstede, 2001). Students growing up in this culture are more familiar with ideas of respecting authorities (e.g., teachers in classroom, elders in a family), avoiding disagreement and conflicts, and saving both one’s own and the other’s ‘face’ at any price (Hofstede & Hofstede, 2005). When studying in a culture that situates Chinese students in an environment that is so different from their home culture, therefore, it is not hard to imagine their hardships and difficulties in learning and especially in learning critical thinking (Atkinson, 1997).

### **American Culture and Critical Thinking**

Ancient Greek philosophers such as Socrates, Plato and Aristotle believed that knowledge and insight should be based on sound evidence through a method of critical and logical probing questioning. American culture and education have been influenced by this philosophy and value questioning as an imperative path to knowledge and truth. Students usually see their teachers as guides and facilitators (Durkin, 2008; Phuong-Mai et al., 2005) who lead them to the truth by the means of questioning (Scollon, 1999).

Teachers encourage students to reason and question in order to clarify and understand knowledge, and to cultivate and develop higher order thinking skills for effective problem solving (Afamasaga-Fuata'i, 2005). They also expect students to present their critical thinking through classroom activities and homework. In American education, critical thinking is regarded as an essential component and has been endorsed as the most important goal of undergraduate education (DeAngelo et al., 2009).

Dewey (1916, 1933) first proposed “good habits of thinking” as a basic principle for the organization of school curriculum (1916, p. 163). Critical thinking became more recognized in education when U.S. government policy—the 1991 National Education Goals Report—mandated college graduates to demonstrate an advanced ability to think critically (National Educational Goals Report, 1991). The Association of American Colleges and Universities has also promoted critical thinking in different fields such as liberal arts studies, cultural studies, STEM, medical education, and science (Association of American Colleges & Universities, 2013). As a result, students in college generally have shown their critical thinking development and growth. Students who start at the 50th percentile on tests of general critical thinking abilities may be lifted up to the 72nd percentile through college education (Huber & Kuncel, 2015). Classroom activities in college (joining group discussions and writing essays) are conducive to developing their critical thinking skills (Bligh, 2000; Bonwell & Eison, 1991; Keeley, Browne, & Kreutzer, 1982; Tsui, 2002).

### **Confucianism Chinese Culture and Critical Thinking**

Traditional Chinese culture has been influenced by Confucianism for thousands of years. It values societal hierarchy and group harmony. It sees the Confucian Doctrine of

the Golden Mean (i.e., it is the optimized and critical third position, situated between the excessive and the less) as an essential aspect in social relations, and believes that everyone has a predetermined position in society. People should behave based on their predetermined rank and social status, and not question this predefined social order (Fan, 1995).

Influenced by Confucianism, students see the teacher as the knower and an authority, who has the knowledge that all students have come for and a vertical power over them. They believe that teachers are always right and so they should never doubt the teacher's knowledge nor argue with the teacher (Zhao, 2007). To show their respect for teachers and maintain group harmony, students usually stay quiet in classes and are mindful of others and their relative positions in groups (Lee & Carrasquillo, 2006; Sit, 2013). After all, Confucianism values *chen mo shi jin, xiong bian shi yin* (*being quiet is gold and vigorously debating is silver*).

Chinese students' quietness and agreeableness in classrooms have been discussed in previous literature. These behaviors are interpreted as not conducive to critical thinking development and performance. For example, Chinese students tended to refrain from "expressing personal opinions especially when these are contrary to the common sense" (Durkin, 2008, p. 16). Carson stated that East Asian students use language as a medium for expressing group solidarity and shared social purpose, instead of personal opinions (Carson, as cited in Atkinson, 1997). Hofstede and Bond (1988) further agreed that East Asian students value harmonious group member relationships more than seeking absolute truth and personal voices, for the latter would unavoidably spark debate. Especially with regard to truth-seeking, a few studies also reported that Chinese students

scored lower on critical thinking test compared to their Western peers (Ip et al., 2000; Tiwari et al., 2003; Ku & Ho, 2010). Lee et al. (2014) emphasized that East Asian students were reluctant to engage in self-expression, debate and argumentation, and direct styles of questioning. Chinese students are also reluctant to show their personal opinions not only in classes, but also in assignments. In writing assignments, for example, they are discouraged to have individual, creative, and innovative autonomy in their writing, but encouraged to memorize and recite instead (Scollon, as cited in Atkinson, 1997, p.83).

### Summary

In summary, in this chapter, I first discussed the nature of critical thinking including *state*, *trait* and *emergent* perspectives (Holenen, 1995), and then reviewed literature on teaching and learning critical thinking, as well as how culture and language affect students' critical thinking. These multiple bodies of literature serve as a conceptual framework to guide the current study. That is, the current study uses the six core skills, seven essential dispositions, and Perry's scheme as basic guidelines to explore participants' understanding of the nature of critical thinking. Meanwhile, literature on critical thinking teaching and learning strategies serve as a framework to explore what teaching and learning suggestions participants may offer in order to improve their critical thinking learning and application. Finally, the literature on language and culture differences provides a comprehensive understanding about the differences, if any, between the two groups of participants' understanding of critical thinking.

Unlike previous research on examining students' performance on mechanical critical thinking tests, the current study tries to listen to students' own voice on critical thinking. If critical thinking has been endorsed by faculty as an essential goal of

American higher education, then it is imperative for researchers and educators to understand the perspectives of students, for they are the ones who will perform this goal.

The scholarly research on critical thinking in this chapter has provided a conceptual framework for answering the research questions of this study:

Central Research Question:

How do Chinese international and domestic junior and senior STEM students perceive and describe critical thinking?

Subquestions:

(1) Do the two groups both believe critical thinking has an important impact on their education and life in general?

(2) What suggestions do the two groups have for their instructors to facilitate their critical thinking comprehension and application?

### **CHAPTER 3. METHODOLOGY**

The purpose of this study is to explore Chinese international and domestic STEM students' perceptions and experience related to critical thinking. In order to carry out the study, the following research questions are addressed:

Central Research Question:

How do Chinese international and domestic junior and senior STEM students perceive and describe critical thinking?

Subquestions:

(1) Do the two groups both believe critical thinking has an important impact on their education and life in general?

(2) What suggestions do the two groups have for their instructors to facilitate their critical thinking comprehension and application?

Phenomenological methods were chosen to answer these research questions. In this chapter, I discuss: 1) the rationale for choosing a phenomenology approach, 2) positionality, 3) data collection, 4) data analysis, and 5) trustworthiness of the study.

#### **Rationale for Choosing A Phenomenology Approach**

The purpose of this study is to understand how STEM students perceive and experience critical thinking in their disciplines. For this purpose, the qualitative tradition was chosen for it honors “a focus on individual meaning and the importance of rendering the complexity of a situation” (Creswell, 2012, p. 32). By focusing on each individual participant's own meaning of critical thinking, the study is able to provide an essence of the meaning of critical thinking that students perceived and experienced. Within qualitative traditions the study specifically adopts the transcendental phenomenology



approach. In the following, I will describe this approach and how it connects with my study.

### **Transcendental Phenomenology**

In the first half of the 20th century, Edmund Husserl (1931) pioneered a new philosophy system that was rooted in *subjective openness*—a radical approach to acquire knowledge of science through “concentrated studies of experiences and the reflective powers of the self” (Moustakas, 1994, p. 25). Husserl’s new philosophical tradition started the movement of phenomenology. To Husserl, phenomenology emphasizes subjectivity and discovery of the essences of experience and so can provide a systematic and disciplined methodology for derivation of knowledge. In other words, phenomenology is back to things themselves (phenomena) and provides the basis of all knowledge (Husserl, as cited in Moustakas, 1994, p. 45).

Based on Husserl’s work and philosophy on phenomenology, Moustakas (1994) discussed the theoretical underpinnings of phenomenology,

Phenomenology is the first method of knowledge because it begins with ‘things themselves’ ...step by step, [it] attempts to eliminate everything that represents a prejudgment, setting aside presuppositions, and reaching a transcendental state of freshness and openness, a readiness to see in an unfettered way, not threatened by the customs, beliefs, and prejudices of normal science, by the habits of the natural world or by knowledge based on unreflected everyday experience (p. 41).

In phenomenology, perception is believed to be the primary source of knowledge and the access to truth. It brings textual descriptions of the experience to life. Multiple and new perceptions can contribute to the knowledge regarding any object (Gurwitsch,

1966). Through perceptions, phenomenological researchers are able to bracket—suspending judgment and assumptions about the natural world—to focus on analysis of the experience, develop full textual descriptions of the experience, and work toward explicating the essential nature of the phenomenon.

Husserl (1913, 1931) introduced the concepts of *neoma* and *neosis*. To him, the content of perception (or a thought, a judgment) is referred as *neoma*; the act of perceiving/understanding the content of perception (*neoma*) is *neosis*. In Ihde (1979)'s words, “*neoma* is that which is experienced, the what of experience, the object-correlate. *Neosis* is the way in which the what is experienced, the experiencing or act of experiencing, the subject-correlate” (as cited in Moustakas, p. 69). For example, in my very first semester studying in the U.S. as a Chinese international student, I perceived assignments requesting my critical thinking input as Swiss cheese—a big circle with many smaller holes. My K-16 education from China overlapped with some of the graduate education I was receiving at that time in a U.S. university, which represents the solid areas on the Swiss cheese. On the other hand, all the knowledge of critical thinking that I lacked represents the holes on the Swiss cheese. The “holes” made me feel incompetent, genuinely confused and frustrated. In my perception of critical thinking assignments, *neoma* is the Swiss cheese; *Neosis* is all my experiences up to that point in which I knew and did not know about critical thinking, including knowledge and abilities that I may have learned in my K-16 education but was not yet familiar enough to uncover in English. These experiences will be discussed in more depth in the section on positionality. The concepts of *neoma* and *neosis* are crucial in exploring the participants' perceptions and experiences of critical thinking, based on their positionality in the world.

In the transcendental phenomenology approach, engaging epoche is a fundamental process and aims to cast doubt on pre-held fundamental beliefs. Epoche is a Greek word meaning “to stay away from or abstain” (Moustakas, 1994, p. 85). Based on Husserl’s philosophy on epoche, Moustakas (1994) says,

Epoche is a preparation for deriving new knowledge, a process of setting aside predilections, prejudices, predispositions, and allowing things, events and people to enter anew into consciousness, and to look and see them again, as if for the first time...Epoche gives us an original vantage point, a clearing of mind, space, and time, a holding in abeyance of whatever colors the experience or directs us, anything whatever that has been put into our minds by science, or society, or government, or other people, especially one’s parents, teachers, and authorities but also one’s friends and enemies (pp. 85-86).

Engaging in epoche is not to deny the reality but to exclude the attitude of “knowing things in advance” (p.85). As a process and a state of mind rather than merely a tool (Walsh, 1988), a researcher needs to constantly carry out epoche throughout the whole study—before the interviews, during the interviews, especially in data analysis stages, and when completing the study. In my study, for example, as the phenomenological researcher, I am susceptible to “the knowing of things in advance” attitude about my participants. With the Chinese international participants, we share the same Chinese culture and similar K-12 education backgrounds probably with very similar teaching styles and curriculum, and so I may have a preconceived idea that they are not generally good at critical thinking and perhaps never paid attention to critical thinking before being interviewed for this study. With the domestic participants, however, I may

hold beliefs that they are generally better at critical thinking than their Chinese international peers. I may also expect them to understand critical thinking more in-depth just like my graduate American peers, because my learning about the American curriculum and peers occurred in my graduate study experience in the U.S. Only through undertaking the epoche process and constantly reminding myself to stay away from my pre-held beliefs, am I able to explore the truth and essence of the study—meanings of critical thinking from the participants' points of view.

To be transparent in the epoche process, my positionality (i.e., pre-held beliefs and past experiences that may influence my position towards the participants before beginning this study) will be discussed in the Positionality section. My bracketing and self-reflectiveness in the data analysis process will be discussed in Chapter Four. In the following section, a brief summary of phenomenology features will be discussed (Creswell, 2012); these features served as a basic outline for me to carry out the study.

### **Creswell's Summary of Phenomenology Features**

Husserl (1931) and Moustakas (1994) introduced and explained this path-breaking transcendental philosophical approach to understand human experience. However, Creswell (2012) clearly summarized the important features that enabled me to use them as basic outlines for carrying out my transcendental phenomenological study:

The purpose of a phenomenological approach is to emphasize and explore a single concept or idea as a phenomenon. Participants are a heterogeneous group who have all experienced the studied phenomenon/concept/idea. Bracketing the researcher out of the study by discussing personal experience with the phenomenon is important in a phenomenology study. Data is collected through

interviews and analyzed from narrow to broader units and then on to detailed descriptions that essentially answer ‘what’ the individuals have experienced (pp. 78-79) [neoma in Husserl (1931)’s words] and ‘how’ they have experienced the phenomenon [neosis in Husserl (1931)’s words] (pp. 78-79).

Following this outline, the purpose of my study is to understand the participants’ perceptions and experience of critical thinking as a phenomenon. Participants are a heterogeneous group: STEM junior and senior students at a large Midwestern research university in the U.S., who have experienced the concept of critical thinking. Bracketing myself as a researcher out of the study is one important part of the epoche process and so I discuss my positionality in the next section. Data collection through one-on-one in-depth interviews and inductive data analysis will be discussed in more detail in Chapter 4 to answer what and how the participants have experienced critical thinking.

### **Positionality**

Knowledge is situated and marked by its origins (Haraway, 1991; Harding, 1991; Rose, 1997). We “see the world from specific locations, embodied and particular, and never innocent” (Rose, 1997, p. 309). Through multidimensional and complex ways, for example, how one person constructs knowledge and observes the world can be vastly different from others. These complex ways of seeing the world are informed and formed by the person’s cultural background, personal values, political stances, and thinking patterns. In qualitative research, similarly, how the researcher perceives and interprets the study and its data is influenced and affected by these complex influences. Therefore, in order to enhance the study’s rigor and trustworthiness, qualitative researchers need to be reflexively aware and monitor their own positionality, or the role of the self, to be

transparently visible during the analysis. Researchers do this by “use of first-person language and provision of a detailed and transparent report of decisions and their rationale” (Berger, 2015, p. 222).

According to Saldaña (2014), positionality refers to a complex combination of the researcher’s gender, age, ethnicity, sexual orientation, economic class, occupation, personal biography, learned experiences, and individual thinking patterns. In the following section, therefore, I first looked inward at my identity/positionality related to the research, and then outward to explain how my positionality may influence the relationship between me and my participants and the study.

### **My Identity/Positionality and The Study**

In my early 20s, I came to the United States to pursue a Master of Arts degree in Applied Linguistics at a small university in Midwest that had a small number of international students enrolled. When I was asked to write a critique paper for the first time by an American professor, I was confused and speechlessly surprised about the assignment, for the word “critique” translates to “negative judgment” (*pi ping*; *pi pan*) in Chinese from the dictionary. Even though I looked up every single word in that assignment question to make sure *pi ping* was the core requirement, I was still confused about my professor’s expectations. My other international peers explained the professor meant “fault finding” from the assigned article. How could I negatively judge or find faults in an article that was already published in a well-known journal? Wasn’t I supposed to memorize or mimic the article instead? Scholars in the field differ in their understanding of Chinese international students’ performance on critical thinking tests and assignments, with some asserting that Chinese students have inadequate critical

thinking (Ten Dam & Volman, 2004; Ip et al., 2000) and others noting that Chinese students can do well on critical thinking performance (Cheng, 2000; Durkin, 2008). However, as a first-year international graduate student, I was not familiar with the concept of critical thinking and how to practice it. I thought *pi ping*—judgment of an article (i.e., pros and cons of the topic in an article) was the concept of critical thinking but I was very surprised and reluctant to “judge” anything in a class. As I reflect back on my thought about critical thinking, writing pros and cons of an article maybe related to some perspectives of critical thinking skills (e.g., analysis, evaluation, explanation; APA, 1990; Paul, 1990) but I was not at all prepared to initiate that “spirit” or critical thinking dispositions (e.g., critical thinking self-confidence, inquisitiveness, open-mindedness; Facione, 2000; Siegel, 1988). Using my interpretation back then, therefore, my first critique assignment was finished as a summary.

This experience of mine was uniquely shaped by my own positionality in the world. I interpreted the word “critique” in the assignment through the unique *lens, filters* and *angles* (Saldaña, 2014) that had shaped me. In the following paragraph, therefore, I discuss my *lens, filters* and *angles*—my identity—regarding critical thinking.

### **My Positionality and The Participants**

Being a Chinese woman coming from a middle-class family in China, I have been influenced by my Chinese K-16 education and teachers, Confucius culture and its impacts on valuing hierarchy, and my own family upbringing which regards education as the pathway for people to leap through the Dragon’s gate. This phrase refers to a Chinese proverb—the carp has leaped through the dragon’s gate--鲤鱼跳龙门(*Li Yu Tiao Long Men*). If a carp successfully makes the jump, it would be transformed into a dragon—

symbol of great power. The proverb is used to express that if a person works hard and diligently, success will one day be achieved. These influences have all instilled in me the values of being a good student with fewer words. In my mind, being a good student means getting good grades and “fewer words” means showing respect and wisdom especially in front of a higher authority figure (e.g., this figure may be a teacher in class, an elder, a school official). My Chinese K-16 education encouraged memorization (e.g., a good student can repeat a whole article from memory) and lots of assignments, but not much public judgment of others’ work especially published pieces. Therefore, writing a critique that involved critical thinking was a foreign and strange concept to me.

With my Chinese international participants, I share the similarities of being an international student in the U.S. (e.g., identity and experiences) and being a native speaker of the Chinese language. These commonalities position me an insider for them. Throughout the participant recruitment and data collection and analysis, this insider role may have allowed Chinese international participants to accept me more quickly and be more willing to share honest and in-depth responses (Dwyer & Bucle, 2009). This insider role requires me to constantly monitor myself not to impose my values and beliefs onto the participants subconsciously, thereby overlooking their authentic voices and opinions—their own positionalities in the world—that are different from mine (Berger, 2015), and blurring boundaries between the participants and me (Drake, 2010).

With my domestic participants, I am more of an outsider and unfamiliar with their experiences—my Chinese culture, language and education experience are all different from them. This role of being an outsider allows me to approach their responses from a fresh and open viewpoint that may lead to innovative directions (Berger, 2015). I may



miss some cues and subtle expressions on the themes from them, but by engaging epoche (Husserl, 1931; Moustakas, 1994) and doing self-reflections throughout the study, I am able to monitor my own interpretations and analysis to maintain their true voice.

In summary, my positionality is to be aware and transparent about how it forms and informs the current research process. It will be discussed again specifically related to how I as the researcher stay away from my prejudgments about the participants in the data analysis section in Chapter Four.

### **Data Collection**

The researcher received Institutional Review Board (IRB) approval from Iowa State University prior to collecting data (see Appendix A). Data was collected through in-depth, one-on-one semi-structured interviews. Domestic participants were interviewed in English, and Chinese participants were interviewed in their native language—Chinese—in hopes of eliminating any possible language barriers that might arise if they were interviewed in English.

### **Participants**

I used purposeful sampling (Patton, 2002) as a way to recruit the participants in this study. Fourteen participants—12 domestic and 2 Chinese international participants—were initially recruited through email invitations (see Appendix B for recruitment details) that were sent out to all STEM juniors and seniors at a large Midwestern research university (see Appendix C for the list of STEM majors in this university). Through the two Chinese international participants, I then used a “snowball” process to recruit another 11 Chinese international participants who were eligible for participating in the study. As a researcher, I concluded that 25 participants in this study allowed me to reach data

saturation, because my ability to obtain additional new information had been exceeded (Guest, Bunce & Johnson, 2006) and further coding was no longer feasible (Guest et al., 2006).

With their permission, participants' demographic information was collected at the beginning of each interview (see Table 2 below). All names are pseudonyms. Chinese international participants were given a pseudonym that starts with the letter C and were in a group labelled as CHINTL, while all domestic participants were given pseudonyms starting with the letter A and were in a group labelled as DOM.

Table 2: *Participants' Demographic Information*

Group	Participants	Major	Year in College	Gender
CHINTL	#1 Cody	Mechanical Engineering	Senior	M
CHINTL	#2 Courtney	Food Science	Senior	F
CHINTL	#3 Casey	Food Science	Senior	F
CHINTL	#4 Claire	Computer Engineering	Junior	F
CHINTL	#5 Charles	Mechanical Engineering	Senior	M
CHINTL	#6 Cynthia	Computer Engineering	Junior	F
CHINTL	#7 Cassandra	Civil Engineering	Junior	F
CHINTL	#8 Connor	Civil Engineering	Junior	M
CHINTL	#9 Cameron	Food Science	Senior	M
CHINTL	#10 Carter	Electrical Engineering	Senior	M
CHINTL	#11 Caroline	Civil Engineering	Senior	F
CHINTL	#12 Colin	Software Engineering	Senior	M

Table 2. (continued)

Group	Participants	Major	Year in College	Gender
CHINTL	#13 Chad	Electrical Engineering	Senior	M
DOM	#14 Arthur	Industrial Technology	Senior	M
DOM	#15 Andy	Electrical Engineering	Junior	M
DOM	#16 Amber	Pre-Vet	Junior	F
DOM	#17 Andrea	Mechanical Engineering	Junior	F
DOM	#18 Alec	Mathematics	Senior	M
DOM	#19 Allen	Chemistry	Senior	M
DOM	#20 Asher	Computer Science	Senior	M
DOM	#21 Aiden	Mechanical Engineering	Junior	M
DOM	#22 Austin	Mechanical Engineering	Senior	M
DOM	#23 Anthony	Electrical Engineering	Senior	M
DOM	#24 Amanda	Biology	Senior	F
DOM	#25 Anna	Industrial Engineering	Junior	F

Table 3 below summarizes the participants' demographic information including their year of college, gender and major. Among all participants, 64% of them are seniors, 68% of them are in engineering majors, and 60% participants are male. Among Chinese participants, 69% are seniors, 77% are in engineering majors, and 54% are male. Among domestic participants, 58% are seniors, 58% are in engineering majors, and 67% are male.

Table 3: *Summary of the Participants*

	Year in College		Gender		Major			
	Junior	Senior	Female	Male	Science	Technology	Engineering	Math
CHINTL	4	9	6	7	3	0	10	0
DOM	5	7	4	8	3	1	7	1
Total	9	16	10	15	6	1	17	1

### Overview of Interviewing Procedure

Interviewing is “useful for collecting detailed information about a person’s thoughts and behaviors” (Boyce & Neale, 2006, p. 3). For phenomenological research that aims to understand the lived experience of other people and the meaning they make of that experience, in-depth interviewing is an ideal approach to use (Seidman, 2006).

In this study, interviews explored participants’ perceptions and experiences of critical thinking within their disciplines. Each interview lasted from 45 to 60 minutes and was audio recorded with the permission of the participant. All participants were asked two demographic questions and nine interview questions. Chinese participants were interviewed in Chinese and domestic participants were interviewed in English. The interview protocol is listed as following:

Demographic information:

1. What is your major? 你的专业是什么?
2. Which year are you in college? 你上大学哪年?

Participant's understanding of critical thinking:

3. Tell me about a time when your teacher/professor asked you to think critically in a course or an assignment. What were your first reactions? How did you respond? How did the experience turn out? 请跟我说一下，你的老师 / 教授要求你在一门课或者一个作业里运用批判性思维的经历。你的第一反应是什么？你怎么回答的呢？这个经历的结果怎样？
4. Tell me about a time when your teacher/professor asked you to think critically but you thought it was not necessary to think critically? Why did you think so? Has your opinion changed? 请跟我说一下，当你的老师 / 教授要求你运用批判性思维而你觉得并不需要用的经历。你当时为什么那么想？你的观点后来改变了吗？
5. How do you think critical thinking is important for your education, career, everyday life, your civic life, and perceptions of knowledge? 批判性思维对你的学习，对知识的理解，对你的教育，对你的以后的事业，每天的生活，以及对你的公民生活？
6. Do you believe critical thinking has been built into the classes in your major at <institution name>? (Probes: If they answer yes, I will ask them to pick one of these classes/their experiences and explain to me how they think so. If they answered no, I will ask them why and how do they think so?)  
你认为批判性思维有植入在你的学科课程里吗？（如果他们回答是，我将会要求他们给我分享其中的一个或几个例子。如果他们回答不是，我将会问他们为什么会这样想，以及和我分享具体例子？）

7. Tell me about the things that have helped or hindered your critical thinking in your classes. How have instructors helped or hindered your critical thinking? What sorts of things could instructors do to facilitate your comprehension and application of critical thinking?

在你的学科课程里，你觉得什么帮助或阻碍了你的批判性思维的运用？具体怎样帮助或阻碍了呢？你觉得，老师教授们可以怎样帮你更好的运用批判性思维呢？

8. In your experience, how do you know if someone is a good critical thinker within your discipline (STEM)?

在你的专业里（STEM），你是怎样判断一个人是否擅长并积极应用批判性思维的呢？

9. What is critical thinking in your opinion? (Probe: please tell me about the concept in your own words).

你觉得什么是批判性思维？（探测式问题：你能用你自己的话告诉我是什么吗？）

In summary, the interviews were used to collect data directly from the participants' understanding and experience of critical thinking. The matrix in Table 4 briefly describes which research question are answered by which interview question(s).

Table 4: *Which Research Question Are Answered by Which Interview Question(s)*

Research Questions	Source of Data:
<b>Central Question:</b> How do Chinese international and domestic junior and senior STEM students perceive and describe critical thinking?	Interview questions 3, 4, and 9 contributed to understanding this central research question.
<b>Subquestions:</b> (1) Do the two groups both believe critical thinking has an important impact on their education and life in general?	Interview question 5 contributed to understanding this subquestion (1).
(2) What suggestions do the two groups have for their instructors to facilitate their critical thinking comprehension and application?	Interview questions 6, 7 and 8 contributed to understanding this subquestion (2).

### Data Analysis

Moustakas (1994) recommends transcendental phenomenological research to answer two questions: *what* were the participants' experiences of critical thinking? And *how* (in what context or situations) they experience it. To answer these two essential questions for the current study, I followed Moustakas' (1994) steps for analyzing transcendental phenomenological data and utilized Moerer-Urdahl and Creswell's (2004) explicit illustrations on analyzing this type of the data.

Moustakas (1994) has suggested a systematic and rigorous approach to organize and analyze data in transcendental phenomenological research. The epoche is the first step—the researcher describes his or her own experience with the phenomenon so that he or she can set aside his or her own prejudgments of the phenomenon, at the beginning of the study. “The task requires that I look and describe; look again and describe; look again

and describe; always with references to textural qualities... [that is] to the things themselves” (Moustakas, 1994, p. 91-92). The epoche is a constant process throughout the whole study. The second step in the analysis procedure is horizontalizing, in which the researcher identifies specific statements related to the topic from the interview transcripts, and then selects and presents the significant ones. The significant statements are called “*Horizons* (the textural meanings and invariant constitutes of the phenomenon)” (Moustakas, 1994, p. 97). From the *Horizons*/significant statements, the invariant statements are clustered into themes or meaning units (Moustakas, 1994). Following the thematic analysis, the researcher then provides descriptions of “what” was experienced (textural descriptions) and “how” it was experienced (structural descriptions). In the last step, after the textural and structural descriptions, the researcher synthesizes and constructs the essence of the phenomenon. The data analysis for this study is discussed in Chapter 4.

Using their qualitative study as an example, Moerer-Urdahl and Creswell (2004) employed the Moustakas (1994)’s steps and exhibited the explicit procedures in their data analysis procedure. Figure 3 illustrates these steps.

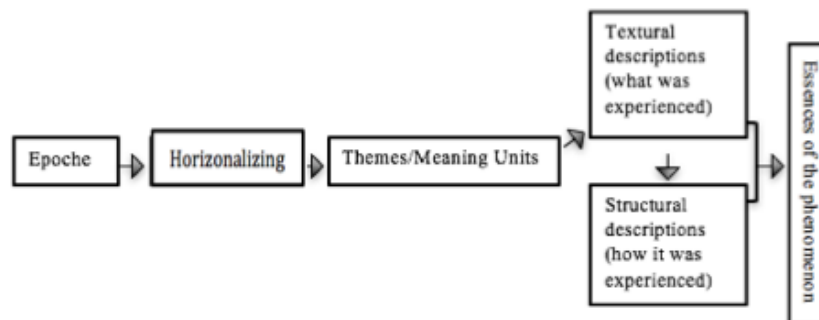


Figure 3. Transcendental phenomenology data analysis procedure



After all 25 interviews were completed, I transcribed the 12 domestic participants' interviews and then translated and transcribed the 13 Chinese interviews into English. I followed the above data analysis steps to explore and interpret the data. The steps of horizontalizing, categorizing themes/meaning units, writing the textural and structural descriptions, and concluding the essence of their experience are discussed in depth in Chapter Four. The following section is the epoche process that I needed to set aside before analyzing the data, because it is specifically related to my critical thinking understanding as a Chinese international student in the U.S.

### **Epoche**

Epoche is a process and state of mind. It should be constantly engaged throughout the study. I shared my positionality earlier in this chapter, and in the following section, I engaged epoche explicitly by sharing and describing my own experience in developing my own understanding critical thinking. Being a Chinese international graduate student studying in a Human Science major, I thought writing critiques and thinking critically were two core responsibilities in my graduate education in the US. The participants from my study are all from STEM majors in which they may need to show their critical thinking in different ways. Therefore, it is even more important for me to engage epoche in order to stay alert about my possible judgments about the participants and their understanding of critical thinking.

I recall four stages that I have gone through which eventually led me to be willing to judge or evaluate an article, a topic, or even an author, which I thought was the concept of critical thinking. As discussed earlier, this understanding is only a small part of a critical thinking definition. Halonen (1995) suggested that the approaches of

understanding critical thinking included *state* perspectives (i.e., abilities and skills), *trait* perspectives (i.e., inherent dispositions), and *emergent* perspectives (i.e., cognitive development).

These four stages I have gone through are 1) being afraid of interrupting harmony; 2) accepting critical thinking expectations with reluctance; 3) going a little overboard in practicing critical thinking; and 4) refining my understanding of critical thinking. Coming from similar Confucius culture and Chinese K-16 education background on a macro level, I believe that some or all of the international Chinese participants in my study may share some similarities with what I experienced through these four stages.

In stage 1, when I was asked to critically think and express an opinion, I was afraid to disturb any potential harmony that I had been taught to maintain by my culture and my Chinese K-16 education. Although I gradually started to become familiar with the challenges of expressing myself in classes, I was unsure of the importance of thinking critically in education at all.

In stage 2, I gradually accepted the importance of writing critiques and critically expressing an opinion in my graduate education. I also started to understand that not all published work is great work. More importantly, I realized that critiques and open communications are beneficial for the work. However, I still struggled to complete critical thinking assignments often requested by my American professors, especially considering I was still an English language learner. If I had problems understanding the content in English in the first place, it was impossible for me to appropriately display my

critical thinking skills. I expect some of the Chinese international participants in my study may hold similar beliefs.

In stage 3, I may have gone overboard with writing and expressing my opinion critically, in my opinion. As I was getting used to the requirements (i.e., writing critiques and expressing my opinions), I found “finding faults” was the quickest and most convenient way to accomplish the assignments with critical thinking listed as one of the requirements (e.g., a critique paper, a critique group discussion). Therefore, I put all my effort into finding faults while I deliberately overlooked the valuable points and pros the topic may have offered. In my opinion, in this stage, I was becoming almost a negative person towards almost every article I read and every opinion I heard.

In stage 4, I realized the mistakes I made in stage 3 and started better understanding the essential aspects of critical thinking, which is not about faultfinding but a mental activity that seeks knowledge and establishing what to do and what to believe (Chiu, 2009). I try to see all sides on topics and opinions. While I look for cons and less valuable/reliable information from a certain topic and/or an opinion, I also purposefully find pros and valuable information from the topic. And more importantly, I start to look at things within their specific contexts and become appreciative of multiple perspectives. I also start to practice critical thinking in my everyday life. This is a starting point for becoming a good critical thinker.

Reflecting through these stages of how my own critical thinking developed over the years, I was able to be transparent and set aside my pre-judgements that may color this research and affect my participants. I have done such reflections repeatedly

throughout the data collection and data analysis, until I felt a sense of closure and was ready to only listen to the participants' experiences and perceptions.

### **Trustworthiness**

To establish the soundness of the current study, I followed Lincoln and Guba's (1985) suggestions on qualitative research trustworthiness: credibility, dependability, confirmability and transferability. Credibility is one of most important factors in establishing trustworthiness (Lincoln & Guba, 1985). It is promoted by using a research method that meets the research purpose and answers the research questions, and also incorporates sufficient triangulations. Choosing the transcendental phenomenological method for the current study is appropriate, for it aims to meet the research purpose and answer the research questions—essentially what were the participants' experiences and perceptions of critical thinking and in what context or situations did they experience critical thinking. Sufficient triangulations are achieved by me bracketing or engaging epoche throughout the whole study. I kept reflexive memos and journals and constantly referred back to them when interpreting my participants' experiences with critical thinking. Without imposing my prejudgment on what I saw, thought, felt, and perceived, the current transcendental phenomenological study established credibility by going “back to things themselves” (Husserl, as cited in Moustakas, 1994, p. 45).

Dependability refers to the findings' consistency and repeatability in a qualitative study (Lincoln & Guba, 1985). Following Moustakas' (1994) suggestions, I determined the research findings through a systematic and structural data analysis procedure. The findings are consistent with the raw data I collected, and even different qualitative

researchers may arrive at similar findings and conclusions using my raw data and engaging epoche.

Confirmability refers to the degree to which the findings are shaped by the respondents and not the researcher's bias, motivation, or interest (Lincoln & Guba, 1985). In transcendental phenomenology, epoche is the first step in coming to know things (Moustakas, 1994). In other words, as the researcher in this study, my first step is "to look with care, to see what is really there, and to stay away from everyday habits of knowing things, people, and events" (p. 85). By excluding my own empirical interpretations and previous affirmations on critical thinking, my biases and motivation and interest were not in the way of my participants' experiences of critical thinking.

The purpose of this qualitative study is not to generalize the findings and interpretations to a larger population or other settings. However, when the researcher provides sufficient information about the self (the researcher as instrument) and the research context, processes, participants, and researcher-participant relationships to enable readers to decide how the findings may transfer (Morrow, 2005). Therefore, I have provided sufficient information earlier about my epoche and positionality, and will provide the detailed data analysis and the study results in Chapter Four so other researchers can evaluate the extent to which they are able to generalize the findings of the current study their own context.

### **Summary**

This chapter discusses the rationale for choosing a phenomenological approach as the study's research method, my positionality related to the study, how I collected and analyzed the data, and how I ensured the study's trustworthiness. A transcendental

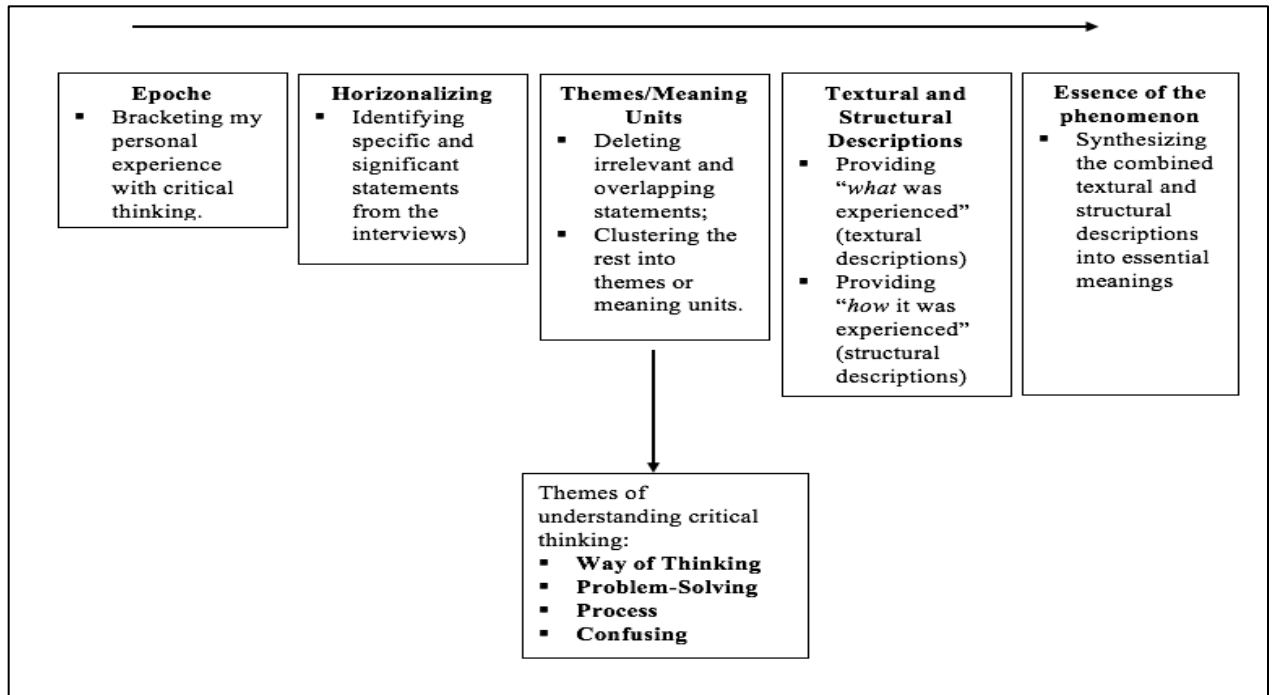
phenomenology approach was chosen because it fits for the research purpose and questions—understanding what and how STEM students perceive and experience critical thinking in their discipline. It provides a systematic and disciplined methodology for derivation of knowledge (Husserl, as cited in Moustakas, 1994) on these 25 junior and senior STEM participants' experiences and perceptions in critical thinking. This approach is a new way of looking at things, a return to things as they actually appear, through reflection on subjective acts (i.e., my positionality and epoche) and their objective correlates (i.e., *what* and *how* the participants have experienced critical thinking).

Data was collected through in-depth on-one-one interviews of 25 participants, and was then analyzed based on the systematic procedures suggested by Moustakas (1994) and further illustrated by Moerer-Urdahl and Creswell (2004). The study built the trustworthiness by ensuring its credibility, dependability, and confirmability and transferability.

## CHAPTER 4. FINDINGS

The purpose of this study is to explore Chinese international and domestic STEM students' perceptions and experience of critical thinking. The central research question was: How do Chinese international and domestic junior and senior STEM students perceive and describe critical thinking? Two subquestions were: 1) Do the two groups both believe critical thinking has an important impact on their education and life in general? 2) What suggestions do the two groups have for their instructors to facilitate their critical thinking comprehension and application?

The infrastructure and nature of the present study is formed based on Moustakas' (1994) phenomenological method illustrations. Guided by his suggestions on how to organize and analyze transcendental phenomenological data, I was able to complete the five data analysis steps: 1) epoche, 2) horizontalizing, 3) clustering themes/meaning units, 4) providing textural and structural descriptions of the phenomenon, and 5) defining the essence of the phenomenon (Moustakas, 1994). According to Moustakas (1994), epoche is used to increase alertness of the researcher's underlying feelings about the research; horizontalizing treats each statement with equal value; and then the meanings are clustered into themes; the themes then are synthesized into a textural description, which will then eventually arrive at a structural description; the essence of the phenomenon is a universal description of the group experience. Figure 4 illustrates my conceptualization of the steps in transcendental phenomenological data analysis and how the themes emerged.



*Figure 4.* Five steps of transcendental phenomenology data analysis

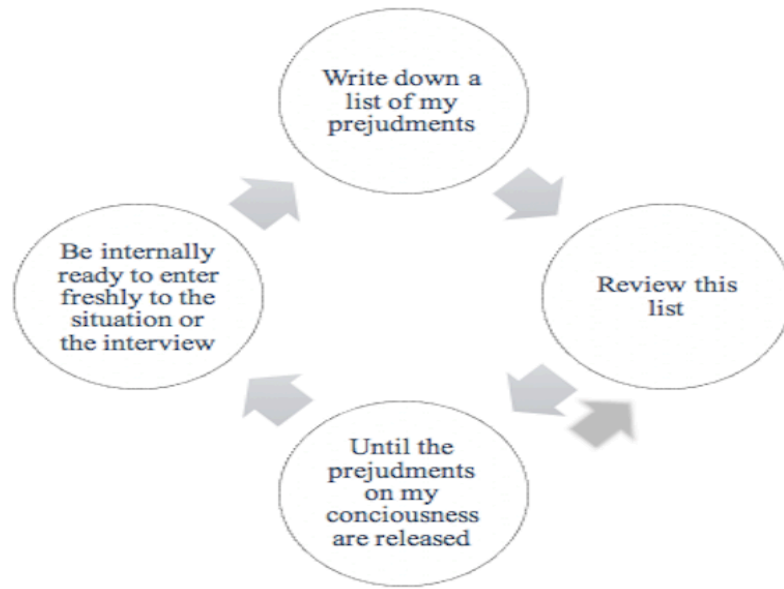
### **Epoche**

Epoche is the first stage to analyze and synthesize transcendental phenomenological data (Moustakas, 1994). It is a process that needs to be constantly engaged throughout the study. In Chapter Three, I discussed part of the epoche—my positionality, including my potential biases from my culture and educational background to the present study and to the participants, and then shared how my experience as a graduate student in the US may have shaped my interpretations of participants’ critical thinking. In this chapter, I share how I have practiced additional epoche in the data analysis process.

Moustakas (1994) recommends explicitly how to set aside your prejudgments when practicing epoche in the data analysis process. Figure 5 lists the steps: step 1 is to write a list of the prejudgments you have related to the study; step 2 is to review and keep



in mind of this list; step 3 is to be ready until the prejudgments are released and the researcher has an internally closure; and the last step is to embrace the situation freshly and openly. The researcher may take step 2 a few times before reaching step 3 (Moustakas, 1994).



*Figure 5. Steps to practice epoche*

Therefore, before I sat down to analyze the interview data, I wrote down a list of my prejudgments towards participants and their experiences and opinions of critical thinking. For example, I wrote down my judgments about two participants: Chad and Austin. Chad is a Chinese international student majoring Electrical Engineering. At the time of the interview in Fall 2017, he was doing his graduation project and going to graduate in December 2017, with an cumulative GPA about 2.5. He came in to the interview about ten minutes later than our scheduled time. Before analyzing his interview transcriptions, I wrote down my pre-judgments about him before the interview analysis:

- I judged his low GPA. As a Chinese student who is graduating, a cumulative 2.5 GPA seems lower than I expect based on my Chinese culture and education perspectives.
- He was late to the interview which in my mind suggested that he may not care much about the interview at all, and maybe he also may not care about his education in general, as indicated by his low GPA.
- At beginning of his interview, he said that his definition of critical thinking was vague and unclear. I thought I completely understood him. However, his understandings and explanations throughout the interview indicated that he had a much better understanding than mine after spending three years in the U.S. Therefore, at that moment, I once again realized the importance of epoche and appreciated Moustakas' (1994) constant encouragement to engage in epoche during/throughout a phenomenological research study. My pre-knowings and assumptions of Chinese students had to be cleared out.

Another student—Austin—is a traditional domestic student studying Mechanical Engineering. At the time of his interview, he was a senior and had a cumulative GPA of 3.9. During the interview, he seemed quiet and even reluctant to answer any questions, even after I confirmed his consent to participate in the study multiple times. The following is my list before I analyzed his interview:

- Austin seemed shy and quiet in the interview. I was not sure how much he would contribute to the study especially at the beginning of the interview. But, he has a high GPA of 3.9. He must know what he is doing for this interview.

- Some of his answers were brief. I had to try to ask him in different ways to get his answers. I felt frustrated. However, I quickly found that his answers were brief but succinct enough for meaning making of his experience in critical thinking.
- I was not comfortable his tone in the interview; it almost felt like he was indifferent to the questions. As a result, I got the impression that he didn't care about the study. After I completed his interview transcription, I sent him a copy asking if I had neglected any of his experience in critical thinking from the interview, and if there were any comments he would like to add. He replied quickly with new comments he made. He is one of the very few participants who returned the transcript with new comments.

When analyzing the interview data, I kept coming back to the lists and tried to clear out my biases to stay immersed with the data. Moustakas (1994) said that

Although epoche is rarely perfectly achieved, the energy, attention, and work involved in reflection and self-dialogue, the intention that underlies the process, and the attitude and frame of references, significantly reduce the influence of preconceived thoughts, judgments, and biases (p. 90).

### **Horizontalizing**

The second step of data analysis in transcendental phenomenological data analysis, *horizontalizing*, identifies the significant statements related to a phenomenon (Moustakas, 1994). In this step, “statement initially is treated as having equal value. Later, statements irrelevant to the topic and question as well as those that are repetitive or

overlapping are deleted, leaving only [core] horizons (the textural meaning and invariant constitutes of the phenomenon)” (Moustakas, 1994, p. 95). These core horizons or significant statements or “the invariant horizons point to the unique qualities of an experience, those that stand out” (p.128). Therefore, after deleting overlapping and repetitive statements from all the initial interview transcripts, I compiled 69 core/invariant horizons or significant statements that described how the participants perceive critical thinking. As shown in Table 5, these 69 verbatim statements shared by the 25 participants described their perceptions of critical thinking:

Table 5. *Relevant and Significant Statements*

Statement Number	Statement	Participant(s)
1	There is no “absolute” in critical thinking.	Chad & Cameron
2	It is thinking comprehensively and not limited to minutiae.	Chad
3	You need to expand and extend your horizons, and jump out of the question itself to see the problem.	Chad
4	In reality, you need to find the best solution, not just a solution.	Chad
5	For me, it is still confusing. Knowing the clear definition would help me better to think critically. Currently its definition is really messy in my mind.	Chad, Cameron & Casey
6	I know how to use it but don’t know the clear definition.	Chad
7	Maybe in the future with more experience and projects, I would know it better.	Colin
8	What is your definition of critical thinking?	Most participants
9	Everything has two sides and so we need to view the question in dialectical.	Colin
10	It is thinking from multiple perspectives.	Carter

Table 5. (continued)

Statement Number	Statement	Participant(s)
11	Making comprehensive conclusions using different factors	Aiden
12	It is knowing how to apply knowledge in real life.	Carter
13	More open-minded and to reduce your biases.	Carter
14	Critical thinking screams problem solving.	Caroline
15	Knowing how and why to solve the problems.	Anthony
16	It is filtering through things and seeing through what's the truth.	Anthony
17	Seeing things in a large rim/context	Anthony
18	Knowing when and how to use your previous knowledge in real life.	Anthony
19	Actively take what you know and figure out something you don't know.	Anna
20	Being rational, creative and grateful	Anna
21	It is reasoning out questions, connecting knowledge, and using what you know to solve what you don't know.	Austin
22	Thinking and comparing, jumping out of boundaries, thinking outside of box, and thinking logically.	Austin
23	It is a process: it is from point A to point B or from 0 to solutions.	Andy
24	You are given no directions but know to use all the skills you know to be creative and less rigid, and think outside of the box in order to solve the problems.	Andy
25	Trial and error.	Alec
26	It is figure out what's wrong.	Andrea
27	Being willing to make mistakes and learn from mistakes.	Alec
28	Modifying your approach and trying not to fail again.	Alec

Table 5. (continued)

Statement Number	Statement	Participant(s)
29	It is important in real life situations.	Alex
30	It is analyzing an argument from multiple viewpoints, and determining whether these views of points are sound, and why or why not they are sound.	Allen
31	Taking information that you are given, examining it with your analytical view, and making informed decisions.	Amanda
32	Willingness to think critically. I hope that I automatically choose it after graduate from college.	Amanda
33	It is something that you have to learn on your own.	Amber
34	It develops so that you can do it on your own once the teacher initiates it	Amber
35	It is starting from the basic knowledge and going deeper. High school teacher taught me to find a question, and come up with a question that is about the question.	Amber
36	Taking basic knowledge and applying it to a deeper level, and expanding it on a wider level.	Amber
37	It is scientific thinking in the most encompassing and efficient way.	Arthur
38	It is analysis and evaluation.	Arthur
39	It can be developed like most other complex skill-sets.	Arthur
40	It is easy once you become habituated to it	Arthur
41	It is logical thinking. [memo: in her interview, she equals critical thinking to logical thinking]	Courtney
42	It is connecting dots.	Courtney
43	It is independent thinking.	Courtney
44	A thousand people have a thousand understanding of it.	Courtney

Table 5. (continued)

Statement Number	Statement	Participant(s)
45	Having your own unique opinions when writing evidence, and having a strong logic.	Courtney
46	It is a mindset or mentality that combines skills with your background knowledge.	Asher
47	Questioning. It is questioning the professor in classes.	Cody
48	It needs to be specific about the questions you are asking. From small points/questions, you can connect them and get the whole picture.	Cody
49	Thinking independently.	Cody
50	It is the way how you use your knowledge.	Aiden
51	When you see something, you know how to criticize it or view it critically.	Casey
52	It means you can have opposite opinions, and you can ask “why” questions.	Casey
53	You should not believe all what others say.	Casey
54	Your critical thinking absolutely decides your independence. The less teachers say, the more you need to think.	Casey
55	It is creativity.	Claire & Caroline
56	With it, things would not be the things they appear.	Claire
57	It is comprehensive thinking	Claire, Cynthia & Cassandra
58	It is less emotional and less impulsive.	Cynthia & Arthur
59	Thinking critically is thinking logically; it is less biased when thinking.	Cynthia
60	It may be transferred to other areas if you care enough.	Caroline
61	Your own independent thinking and understanding process, after which you compare your results with others.	Charles
62	It is the analysis of essence of things.	Connor

Table 5. (continued)

Statement Number	Statement	Participant(s)
63	It is prediction of future.	Connor
64	Your analysis skill will be improved in it.	Connor
65	Thinking more from different perspectives.	Cameron
66	Things have two sides: pros and cons.	Cameron
67	It is important to their education and careers.	All participants
68	It maybe important to everyday life but I don't use it all the time because thinking is tiring.	Cameron, Anna, Courtney & Asher
69	Critical thinking is definitely tiring and so people don't like to think and would rather watch TV instead.	Anna

### Themes and Meaning Units

Moustakas (1994) notes that after the researcher carefully examines the identified significant statements, he or she then clusters the significant statements into the themes or meaning units. Therefore, after I carefully examined the 69 core/invariant horizons or significant statements listed above, four textural themes and six subthemes emerged from this analysis describing participants' understanding of critical thinking. The four textural themes that described participants' understanding of critical thinking were: (1) critical thinking is a way of thinking, (2) critical thinking is problem solving, (3) critical thinking is a process, and (4) critical thinking is confusing. The first textural theme included two subthemes describing how participants viewed critical thinking is a way of thinking: (a) thinking comprehensively, and (b) thinking logically. The second textural theme comprised two subthemes describing critical thinking related to problem solving: (a) solving problems in real life situations, and (b) specific skills need to solve problems. The



third textural theme consisted of two subthemes that describe critical thinking as a process: (a) skill growth process, and (b) habits growth process. The fourth textural theme did not have subthemes. Table 6 illustrates the four textural themes and their respective six subthemes.

Table 6. *Four Textural Themes and Six Subthemes*

	Textural Theme One: Way of Thinking	Textural Theme Two: Problem Solving	Textural Theme Three: Process	Textural Theme Four: Confusing
Subtheme one	Thinking comprehensively	Real life situations	Skill growth process	N/A
Subtheme two	Thinking logically	Specific skills needed	Habits growth process	

Next, I reviewed the reduced list of 69 significant statements and grouped each statement within the textural themes and subthemes. Table 7 is an illustration of the 69 significant statements and their relationship to the four textural themes and the six respective subthemes:

Table 7. *Significant Statements and Relationship to Textural Themes*

Textural Theme	Subtheme	Significant Statement	Participant(s)
Way of Thinking	Thinking comprehensively	1-There is no “absolute” in critical thinking.	Chad, Cameron
		9-Everything has two sides and so we need to view the question in dialectical.	Colin
		10-It is thinking from multiple perspectives.	Carter
		11-Making comprehensive conclusions using different factors.	Aiden
		17-Seeing things in a large rim/context.	Anthony

Table 7. (continued)

Textural Theme	Subtheme	Significant Statement	Participant(s)
		30-It is analyzing an argument from multiple viewpoints, and determining whether these views of points are sound, and why or why not they are sound.	Allen
		37-It is scientific thinking in the most encompassing and efficient way.	Arthur
		42-It is connecting dots.	Courtney
		52-It means you can have opposite opinions, and you can ask “why” questions.	Casey
		56-With it, things would not be the things they appear.	Claire
		57-It is comprehensive thinking.	Claire, Cynthia & Cassandra
		65-Thinking more from different perspectives.	Cameron
		66-Things have two sides: pros and cons.	Cameron
		67-It is important to their education and careers.	All participants
	Thinking logically	23-Thinking and comparing, jumping out of boundaries, thinking outside of box, and thinking logically.	Andy
		41-It is logical thinking.	Courtney
		45-Having your own unique opinions when writing evidence, and having a strong logic.	Courtney
		58-It is less emotional and less impulsive.	Cynthia & Arthur
		59-Thinking critically is thinking logically; it is less biased when thinking.	Cynthia
		67-It is important to their education and careers.	All participants

Table 7. (continued)

Textural Theme	Subtheme	Significant Statement	Participant(s)
Problem Solving	Real life problems	3-You need to expand and extend your horizons, and jump out of the question itself to see the problem.	Chad
		4-In reality, you need to find the best solution, not just a solution.	Chad
		12-It is knowing how to apply knowledge in real life.	Aiden
		14-Critical thinking screams problem solving.	Caroline
		15-Knowing how and why to solve the problems.	Anthony
		16-It is filtering through things and seeing through what's the truth.	Anthony
		18-Knowing when and how to use your previous knowledge in real life problems.	Anthony
		24-You are given no directions but know to use all the skills you know to be creative and less rigid, and think outside of the box in order to solve the problems.	Andy
		26-It is figure out what's wrong.	Andrea
		29-It is important in real life situations.	Alec
		31-Taking information that you are given, examining it with your analytical view, and making informed decisions.	Amanda
		47-Questioning! It is questioning the professor in classes.	Cody
		48-It needs to be specific about the questions you are asking. From small points/questions, you can connect them and get the whole picture.	Cody
		63-It is prediction of future and be prepared to solve new problems.	Connor
		67-It is important to their education and careers.	All participants

Table 7. (continued)

Textural Theme	Subtheme	Significant Statement	Participant(s)
	Specific skills needed	13-More open-minded and to reduce your biases.	Carter
		19-Actively take what you know and figure out something you don't know.	Anna
		20-Being rational, creative and grateful.	Anna
		21-It is reasoning out questions, connecting knowledge, and using what you know to solve what you don't know.	Austin
		36-Taking basic knowledge and applying it to a deeper level, and expanding it on a wider level.	Amber
		38-It is analysis and evaluation.	Arthur
		39-It can be developed like most other complex skill-sets.	Arthur
		43-It is independent thinking.	Courtney
		44-A thousand people have a thousand understanding of it.	Courtney
		49-Thinking independently.	Cody
		51-When you see something, you know how to criticize it or view it critically.	Casey
		54-Your critical thinking absolutely decides your independence. The less teachers say, the more you need to think.	Casey
		62-It is the analysis of essence of things.	Connor
		64-Your analysis skill will be improved in it.	Connor
		55-It is creativity.	Claire & Caroline
		67-It is important to their education and careers.	All participants

Table 7. (continued)

Textural Theme	Subtheme	Significant Statement	Participant(s)
Process	Skills growth	23-It is a process: it is from point A to point B or from 0 to solutions.	Andy
		25-Trial and error.	Andy
		28-Modifying your approach and trying not to fail again.	Alec
		33-It is something that you have to learn on your own.	Amber
		34-It develops so that you can do it on your own once the teacher initiates it.	Amber
		35-It is starting from the basic knowledge and going deeper. High school teacher taught me to find a question, and come up with a question that is about the question.	Amber
		50-It is the way how you use your knowledge.	Aiden
		61-Your own independent thinking and understanding process, after which you compare your results with others.	Charles
		67-It is important to their education and careers.	All participants
	Habits growth	27-Being willing to make mistakes and learn from mistakes.	Alec
		32-I hope that I automatically choose it after graduate from college.	Amanda
		40-It is easy once you become habituated to it.	Arthur
		46-It is a mindset or mentality that combines skills with your background knowledge.	Asher
		53-You should not believe all what others say.	Casey
		60. It may be transferred to other areas if you care enough.	Caroline

Table 7. (continued)

Textural Theme	Subtheme	Significant Statement	Participant(s)
Confusing		67-It is important to their education and careers.	All participants
		68-It maybe important to everyday life but I don't use it all the time because thinking is tiring	Cameron, Anna, Courtney & Asher
		69-Critical thinking is definitely tiring and so people don't like to think and would rather watch TV instead.	Anna
		5-For me, it is still confusing. I know how to use it but don't know the clear definition.	Chad, Cameron & Casey
		6-Maybe in the future with more experience and projects, I would know it better.	Colin
		7-Knowing the clear definition would help me better to think critically. Currently its definition is really messy in my mind.	Chad & Cassandra
		8-What is your definition of critical thinking?	Most participants
		67-It is important to their education and careers.	All participants

### **Textural Descriptions: What was experienced in understanding critical thinking**

The fourth stage of analysis in transcendental phenomenology is developing textural descriptions of the participants' experiences. In this stage, I synthesized the 69 significant statements and the themes into textural descriptions of participants' experiences of understanding critical thinking (Moustakas, 1994). The textural descriptions are based on the direct examples provided by the participants during the interviews. I created a textural description for each of the 25 participants; four selected

individual textural descriptions are described below to illustrate how each of the four participants experienced the themes of understanding critical thinking as a way of thinking, problem solving, a process, and confusing.

### **Individual Textural Description of Cameron: Critical Thinking as Way of Thinking**

Cameron is an international Chinese student majoring in Food Science. At the time of his interview, he was graduating that semester with his Bachelor's degree. Cameron thought it was very important to think critically in his education and career. He described critical thinking as thinking from multiple perspectives and thinking relatively especially when solving problems:

thinking from multiple perspectives, noticing that everything has its positive sides and its negative sides. Keeping this in mind, then you would not say in certainty that this particular solution, for example, is right or wrong. In other words, everything is not 100%...everything is relative. It is like Albert Einstein's Theory of Relativity. It is not absolute to say that an object is fast. There are always some objects are faster. We can only say that this object is faster than a relatively slow object. (Cameron interview, 11/23/17)

Cameron emphasized the important role of perspectives in thinking critically and finding good solutions to some problems. He mentioned that, before he came to study as an international student in the U.S., he was not even aware that a lot of things can be thought of and seen from so many different perspectives. To him, this way of thinking changed his perspectives on understanding problems and broadened his mind to find more feasible solutions. This way of thinking from multiple perspectives is not just a method but rather a drive that propels one to do things more inclusively. He felt that, after

he has seen and learned different things and topics in his years in college, thinking comprehensively has allowed him to be in the place where he is and to look at everything from both sides and refrain from making an either-or decision.

### **Individual Textural Description of Anthony: Critical Thinking as Problem Solving**

Anthony is domestic student majoring in Electrical Engineering. At the time of his interview, he was a senior and planning to graduate the following semester. He also thought critical thinking was crucial to his engineering studies and future career but did not use it much in his everyday life. In Anthony's interview, he constantly stressed that critical thinking was equal to problem solving:

I mean it [critical thinking] just screams problem solving, which I have been saying all the time. If you don't think critically and don't know how to solve problems.... Have you been [on?] a job and work with someone and after working with them for a while you realize they are just basically useless? You know...they don't do their job very well. They are not good at their job. If an engineer who don't think critically and don't know how to solve problems, I think that is going to be the engineers they are going to be useless and waste of the space. I mean, if you can't think critically, they [engineers] are basically useless. (Anthony interview, 09/27/2017)

Anthony thinks that critical thinking has allowed him to know how and why to solve problems especially in his field of Electrical Engineering. Once you know how to think critically, he said, "You would have this ability to filter through and see through of [all the information] and to see what is the truth." He understood the importance of "feeling the problems in a larger rim of scheme of things, and then being able to use



facts, figures, and math equations and apply them into real life/job situations, and use them in a practical manner.” He perceived thinking critically as solving problems.

### **Individual Textural Description of Andy: Critical Thinking as A Process**

Andy is a domestic student majoring in Electrical Engineering. At the time of his interview, he was a junior at this university. Andy also viewed critical thinking as crucial to his engineering education and his future career including his internships. He understood critical thinking as a process of “getting from point A to B, from zero to the solution” and emphasized the importance of thinking independently:

It is a process. It's kind of coming with thoughts and ideas out of scratch, like it's...because you know lots of concepts and facts, and just be able to use and put all those together. I think it's like a puzzle to get the solution. Be able to use everything you know to get the solution...The process can be really frustrating, but then when it gets done it's really rewarding. I know a lot of people complain and complain and I guess they need a lot of thinking [practice]. Some people started STEM majors and expect everything is given to them—all the solutions and all the information. That's not the case with critical thinking, in my opinion.  
(Andy interview, 09/20/2017)

He stressed constantly that students were supposed to be given no directions in this process as engineering majors and so had to use all the information that they knew to “be creative and less rigid, and think outside of the box in order to solve the problems.” The problems he referred mainly lay in his studies—homework and projects and in his future engineering jobs where he would be asked to solve problems without directions. Therefore, he saw those who figure out solutions quickly or start to click quickly as

exemplary critical thinkers because these people shorten the thinking process by using their skills and knowledge. That is, in the process of thinking critically, one not only practiced the thinking skills but also strengthened their understanding of the knowledge.

### **Individual Textural Description of Colin: Critical Thinking is Confusing**

Colin is an international Chinese student majoring in Software Engineering. At the time of his interview, he was a senior and graduating that semester. To Colin, critical thinking was important to his education and future career but he still thought the definition/explanations could be clearer. Although some of his answers involved the aspects of using analysis and evaluation to find solutions (part of the perspectives of critical thinking as mentioned in Chapter Two), he still thought it was confusing:

It would be helpful if I know for sure what critical thinking is. Then my questions would be different if I know the real meaning of this terminology [i.e., critical thinking]. My answers would be different too. I would know how to answer the questions based on the clear meaning of it [critical thinking] ...In English class for example, the teacher did not teach us what critical thinking is but only told us to think critically. (Colin interview, 10/18/2017)

If the phrase—critical thinking—was not listed on a class syllabus, Colin said he would not want to think critically. Colin’s interview was conducted in Chinese as mentioned in Chapter Three, but I used “critical thinking” in English throughout the interview, so I asked him what he would translate the term “critical thinking” into Chinese. He said, “looking at the problems in dialectical” (辩证法看问题 *bian zheng fa kan wen ti*). Although he expressed his frustration and confusion about the nature of

critical thinking, he thought generally it was important to think critically in his education and future jobs where he would need it to build his relationships with colleagues.

### **Developing Structural and Composite Descriptions/ Imaginative Variation:**

#### **How “Understanding Critical Thinking” was Experienced**

In this stage of analysis in transcendental phenomenological research, the researcher uses imagination from divergent perspectives, positions, and roles to seek structural descriptions of an experience (Moustakas, 1994). In other words, the aim of the structural stage of data analysis is to uncover “the underlying and precipitating factors that account for what is being experienced...how did the experience of the phenomenon come to be what it is” (Moustakas, 1994, p. 98). In this section, I first share three individual structural descriptions and, then the composite textural and structural descriptions of the participants’ critical thinking experiences and understandings.

#### **Structural Description of Anna: Homework and Interactions**

Anna is a domestic student majoring in Electrical Engineering (EE). She was a junior at the university at the time of her interview. Anna mainly formed her understanding and perceptions of critical thinking from her experiences in exams, homework, and interactions with her professors. She shared how she thought of critical thinking in exams and homework:

You know they [professors] teach you the exact steps on how to do things, and then you go to exam and homework questions seem nothing like something you studied before. So you can't really just rigidly take the work. So I would say that was how I learned critical thinking—trying to take what I know and apply it to this new question that I've never seen before and hopefully figure it out.

In one of her manufacturing lab homework assignments, Anna was concerned about how she should proceed to solve the problems without having the professor's explicit instructions. In this homework, she was introduced a new program and then asked to use online tools (e.g., YouTube videos) to solve the problems and then present her results in a rational, logical way. She said at first she felt "frustrated" and the homework was "really hard" because no directions were given and she had to do it on her own. This is where she thought she used her critical thinking skill most because "I have to be rational and reason out all the problems and questions using my previous knowledge." Connecting previous knowledge to solve current problems is one of Anna's perceptions of critical thinking.

Through interacting with her professors, Anna was constantly reminded that engineers should figure out problems by themselves. "My whole major is critical thinking, so I think it is very important for us engineers," said Anna. She felt her professors had purposefully asked the engineering students to learn from their own frustrations so that students learn and remember better. "You know when you try something on your own and you get it wrong. And then you try it again, and again and again, and you finally get the right answer, you are going to remember better than if you just look at the solution first and then try to do it." She also thought one-on-one interactions with professors during their office hours improved her critical thinking and learning in general:

Sometimes during lectures, they [professors] skip a lot of steps... when you are one-on-one with your professor and go through the problem-solving process, and also they are the experts of what you study or what you are trying to understand, it

is really helpful to see how they think through the process. So getting time to ask them about your specific questions probably is the most helpful thing in my opinion. You may watch a video on YouTube but there's something clicking and you need someone to teach and show you, you need a human person to do it for you. Otherwise it's hard to do it on your own. This process you learn to think clearly and critically.

### **Structural Description of Chad: Hands-on Projects**

Chad is an international Chinese student also majoring in Electrical Engineering (EE). He was finishing his senior project at the time of his interview. The first time Chad was asked to think critically in an assignment in his freshmen year, he did not know how to respond; “I remember I just did not know how to start. After getting the homework, it was very much inexplicable about what exactly the teacher wanted from me.” After studying in his major for more than three years, Chad said he had a partial understanding of critical thinking.

He concluded his understanding of critical thinking drew mainly from his experiences in authentic hands-on projects that he had completed. “Because the problems we [engineering students] face after we graduate are very, very practical problems in the future. The more practical problems, the more you need to have this critical-thinking skill,” Chad said. He then shared with me one of his experiences doing these projects. He said that the goal of that project was to make a circuit design for a company. Chad and his teammates initially had two plans with plan A being the optimal one. They had to choose a valid location for the wire: it needed to be geologically valid—for example,

neither on the bank of a river nor on private land. However, the initial location from their plan A on blueprint turned out as not geologically valid. So,

In this case, we could erase off the whole plan A and go to the alternative plan B, or we could just make minor changes in plan A—avoiding this particular location. But you need to keep in mind that it could be like a domino effect when you make changes in a plan...[in addition] we also had to use the least amount of money from the company. Therefore, the critical thinking part needed to be applied at its finest. When the problem involves the actual situation, you need to take care of different requirements in all aspects. That is to say that the final optimal solution is not necessarily the only solution you have.

Through solving these real-life problems in these projects, Chad learned how to balance different perspectives and consider all important aspects when solving a problem. Thinking comprehensively was one of Chad's main perceptions of critical thinking.

Besides projects, Chad thought labs were also practical to exercise critical thinking. For example, “you learn the electrical characteristics of a device in labs while you learn theories and memorize facts of this device in lectures.” Chad said these hands-on experiences had helped him greatly in terms of thinking critically and learning better.

### **Structural Description of Amber: Research Experience**

Amber is a domestic student majoring in pre-veterinary and was a junior at the time of her interview. Like Chad, Amber also thought the hands-on experiences defined her understanding of critical thinking—a learning process from shallow to deep and involved with analysis, interpretation and evaluation. She thought critical thinking was crucial to her major:

because you don't see the same things a lot...you would get a new case and you have to be able to see something's wrong with the animal, and figure out what it is that's wrong. That requires critical thinking, because it might not be something you know or remember very well [and your patients do not talk]...You have to be able to make the connections...and figure out, due to different tests, figure out what exactly it is and treat the patient.

The hands-on experiences mainly were from labs and experiments. In these labs and experiments, Amber said she was able to apply the knowledge from textbooks, observe the experiment process, interpret things, scrutinize in-depth questions and do some research by herself.

In a Biology lab class, Amber did a complete research project by herself. She first chose a hormone research topic that she was interested in, wrote a project proposal and got it approved by her professor, and then she carried out the research to test her hypotheses with the help from her Teaching Assistant. In this research project, after studying different hormones, Amber applied one particular hormone on her sample seeds, observed the seeds grow, and after the experiment she wrote an essay analyzing the results, explaining what went well and what needed to change in this experiment, and reasoning what may have affected that specific hormone and how the seeds with this hormone were different from a control group. This research experience helped Amber gain skills including interpretation, analysis, evaluation, and problem solving, which were all important aspect of her understanding of critical thinking. Although the research experience can be “challenging and frustrating at times,” Amber thought it helped her understanding knowledge better compared to standard tests:

Standard test[ing] is overwhelming and the testing centers are...I hate testing centers. It's opposite of critical thinking. You do not have to think those situations where it's all multiple-choice questions and all you just have to do is to recall information, for the most part. Critical thinking is more essay format, interpreting, applying the information and elaborating on it.

### **Composite Descriptions: Experiencing and Understanding Critical Thinking**

I concluded this stage of analysis by creating composite textural and structural descriptions of the participants' experiences and understanding of critical thinking. Moustakas (1994) suggested developing a composite textural description in which the invariant meanings and themes of every participant are studied in depicting the experiences of the group as a whole (pp. 137-138), and creating a composite structural description which is "a way of understanding *how* the co-researchers [participants] as a group experience *what* they experience" (p. 142).

**Composite textural description.** Participants provided vivid examples of their understanding of critical thinking as a way of thinking, problem solving, a process, and sometimes confusing. The following section illustrates their examples.

***Experiencing/understanding it as a way of thinking.*** Multiple participants recounted their experiences of understanding critical thinking as a way of thinking—thinking comprehensively and thinking logically. Chad described it as a comprehensive thinking because he thinks it can satisfy the majority when solving problems and finding solutions. "There is no absolutely right or wrong," Chad said. Similarly, Carter described it as a way to think from multiple perspectives. "If you can think from multiple perspectives, you can extend [the knowledge] to different fields. Then you learn to



connect these different fields of knowledge to solve the problem.” Allen also considered critical thinking as a way to think and analyze from multiple points before making a decision. He thought that people who do not think critically tend to be polarized in their opinions and may become confused when new information is presented. Other participants related thinking critically as thinking logically. Courtney equaled critical thinking to logical thinking and said “when you think critically, you have to use your logic to prove your point of view, like how you write an argumentative paper.” In order to be logical and think critically, both Cynthia and Arthur recommended staying less emotional and being less impulsive. Arthur mentioned the importance of being less impulsive and remaining logical when trying to think critically:

The impulsive is contradictory to critical thinking because it is too quick and people made their decision only based on a few things... [and] overlooked all the other variables of that decision. I've seen more often where that has come to backfire and really just end up in more work in the future work, nothing bad just more work.

***Experiencing/understanding it as problem-solving.*** Some participants emphasized critical thinking as similar to problem solving skills. There were 17 out of 25 participants from the field of Engineering. Their tendency to relate critical thinking as problem-solving skills was clearly shown in their interviews. Anthony understood critical thinking as it “screams problem solving.” Caroline regarded critical thinking as a very important problem-solving skill to have as engineers because when engineers need to solve real problems especially in job situations, they need to find the solution that best fits the needs, not just a solution. In order to solve problems, multiple participants

described necessary skills needed for thinking critically. Arthur, Amber and Allen all mentioned the importance of analysis, evaluation, and inquisitiveness in thinking critically. Carter, Claire and Caroline mentioned open-mindedness, self-judgment, independence, and creativity.

***Experiencing/understanding it as a reasoning process.*** Multiple participants also think of critical thinking as a process. Andy described it as a process of trial and error, in which you learn from your mistakes. Alec thought that critical thinking made you constantly modify your approach until you succeed in solving the problems. Amber also mentioned it as a process where you start from the basic knowledge and then go deeper. In this process, you gradually develop the skills so that you can do it on your own eventually. Amanda pointed out that she learned a lot from the process of thinking critically in her college years so far, and hoped she could “continue to be willing to think critically after [she] graduates.” Both Arthur and Asher mentioned this process as a mental growth process and eventually it would become easier once it was habituated in your mind. Casey described it as a mental tool that shields you from false information and credulity. In order to mentally grow accustomed to it requires patience and practice, because “thinking is tiring” and “critical thinking is definitely tiring and so people don’t like to think and would rather watch TV instead,” said Anna.

***Experiencing/understanding it as a confusing concept.*** Although all 25 participants described and explained their understanding and experience with critical thinking, some of them also clearly showed their confusion on this terminology. Five Chinese international participants explicitly expressed their wishes to understand what critical thinking was so that they could apply it better into their studies. Both Chad and

Cameron described it as a confusing concept, Colin hoped more experience with critical thinking may help him understand what it is in the future. For Casey, she still understood it as confusing although she said she could answer questions based on her understanding of what thinking critically means. While as a qualitative researcher I could not lead my participants by sharing information, most of the participants did ask me at beginning of their own interview what I thought of critical thinking.

Despite the fact that they have different perspectives towards critical thinking, all of the participants considered it important for their education and careers including their internships. For example, Cody said it helped him understand the knowledge and concepts better in his studies. Similarly, Carter also thought knowledge would be learned and applied better in job situations through critical thinking. Caroline mentioned how much her colleagues from her internship appreciated her original thoughts. Allen said critical thinking would keep him updated in his academic field since “it is rapidly changing.” However, they considered it less important and showed less willingness to apply it in their everyday lives. Most of them thought it was still important to some degree, but “thinking is tiring” and “critical thinking is definitely tiring and so people don’t like to think and would rather watch TV instead,” said Anna. So they did not show much enthusiasm using it in their everyday lives. Andy told me he used a microwave to toast bread for his roommates instead of buying a new toaster, which is a way he applied critical thinking in an everyday life situation. However, he disagreed it was necessary to do so for other things in his everyday life. Arthur thought he used critical thinking skills to save up the money he would usually use to buy coffee, and started to make a list before going grocery shopping. Cynthia thought that critical thinking helped her avoid thinking

and shopping impulsively. Cassandra mentioned she would try to think critically the next time she was apartment hunting.

**Composite structural description.** The composite structural descriptions in this section illustrate the contexts in which the participants experienced critical thinking. The composite structural descriptions reveal two underlying themes that contributed to how the participants experienced critical thinking: (a) interactions with professors and peers; and (b) hands-on research and project experience.

***Interactions with professors and peers.*** Multiple participants emphasized the importance of dialogues and interactions with professors and peers on their understanding and application of critical thinking. The importance of dialoguing and interacting with professors mainly included (a) questions being asked between students and professors; and (b) professors modeling critical thinking to students. For example, Casey thought asking professors a lot questions was helpful because it would make her understand the content deeper, and the practice of asking questions and get them answered by experts (professors) could help her decipher how to analyze questions and engage in the process of thinking critically. She referenced an example where one of her professors asked a series of detailed questions that seemed unrelated at first, then after students analyzed and connected all these small questions, they saw the final answer to the question. “It’s like, wow, you didn’t know how to solve that big question at first but with this type of interaction and dialogues, you now know how and it is fun,” Casey said. Arthur thought interacting with professors in class was particularly useful because your points of confusion would be answered immediately, which was a convenient pathway to thinking critically. However, due to people’s “fear of public speaking,” there were not enough

interactions and dialogues in class. Amber also agreed that the professors who ask many “why” questions can initiate the critical thinking process and eventually lead the students to do it on their own.

Several participants appreciated the professors who modeled the process of critical thinking so that they can imitate it on their own in the future. For example, both Amada and Andrea especially valued their experience when the professors showed the class how they solved a problem using a real world example. The engaging questions they asked and the clear steps they used to solve the problem were exemplary for the students to master and learn how to think critically. When presenting and modeling their process of critical thinking, Cynthia and Austin said that real world examples in classes and homework helped them master the imitation better.

In addition to dialogues with professors, some participants also valued their meaningful interactions with their peers in small group work. Cody, Anthony and Anna all explained that meaningful small group discussions had helped their critical thinking because communications made their ideas and thinking become more and more clear. Each person’s ideas and thinking may be different but this debate-like communication with everyone helps clearing up confusion and misunderstandings. “This is why you are wrong, or why my solution better fits under this circumstance, or I think this is where you get your solution misled,” Cody said. In addition to helping critical thinking, Anthony said his group members formed a special friendship which even supported him in hard times; Anna on the other hand felt small group discussions became less meaningful when some members were not contributing to the work at all.

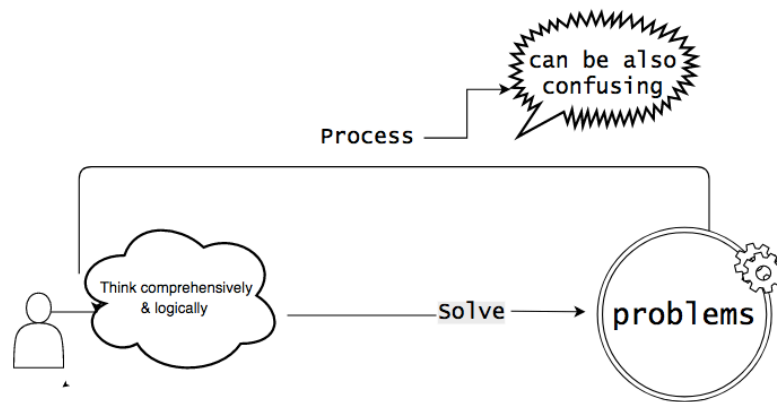
***Hands-on research and project experience.*** Most participants provided their understanding of critical thinking within the contexts of doing a hands-on project, research, or lab homework. Asher mentioned three of his Computer Science courses and how he developed critical thinking in the projects from these courses. Both Cameron and Casey described their experiences of making new food products in their labs—Cameron made chicken waffles and Casey made liquid yogurt. Through the process they both learned to think critically and comprehensively to overcome the difficulties that may only occur in real life projects. Cody mentioned how the process of doing a hands-on project from one of his mechanical engineering classes had helped his critical thinking:

I worked with my teammates to design a water transport tool for people in Africa. We had to think critically and carefully for this project because many different factors had to be considered: what material is afforded, local economy, local road conditions, etc. After we debated and communicated in our group, we came up [with] a design. In the end of the semester, we not only presented our design and showed the prototype of our design, we also needed to sell it in market. These were something I would never think of if I had not done this hands-on project.

### **The Essence of Understanding Critical Thinking**

The final step of Moustakas' (1994) data analysis in transcendental phenomenology is to develop “an integration of the composite textural and composite structural descriptions, providing a synthesis of the meanings and essences of the experience” (p. 144). This section is a synthesis of the meanings and essences of the experience in understanding critical thinking among these 25 participants.

In essence, the 25 participants experienced critical thinking as an aid to help them solve problems and support their learning in general. They considered it important especially for their education and careers. Four themes are categorized into this understanding, and Figure 6 illustrates the interwoven relationships between the four themes, and an integration of the four themes into one understanding—to help them solve problems better and improve their learning in general. In the section that follows, I present each of the four themes as a key dimension of the essence of critical thinking.



*Figure 6.* Relationships among the four themes

*Way of Thinking:* Participants described critical thinking as a comprehensive and logical way to think. With this way of thinking, the participants believed that they would be able to see the problems in their homework, exams, and projects with a comprehensive, inclusive, and logic mind. Critical thinkers would be less biased, less rigid, and more open-minded and inquisitive when encountering opinions and decisions are different from theirs. When making decisions in research projects, for example,

thinking comprehensively and logically means that the person would consider all possible aspects but not fixate on minutiae with a mindset of “no absolutes.”

*Problem solving:* Critical thinking was understood as a practical tool to solve problems. To the participants, the main function of critical thinking is to effectively “figure out what is wrong” and make informed decisions through “questioning,” “examinations,” “analysis,” and “evaluation.” Solving problems as the end goal of critical thinking would allow one to foresee and predict unexpected problems along the process, and fix them efficiently with more well-rounded solutions. Problems can be from real life scenarios in labs, authentic research projects, group work, and homework. Through utilizing critical thinking in problems-solving, participants believed that some specific “skill-sets” were needed including: rationality, creativity, empathy, independent thinking, analysis, evaluation, reasoning.

*Process:* With problem solving as an end goal, participants also regarded critical thinking as a process. The process can be tiring but it is valued for advancing their education and careers. Some participants, however, lack motivation to apply it in everyday life situations. It is a process of “trial and error” and “from 0 to solutions.” Through this process, participants practice their skills and cultivate good thinking habits. That is, from the process, some specific skill-sets that are needed in problem solving will be advanced and expanded, and necessary thinking “mindset” or “mentality” will gradually become “habituated” and maybe “transferred to other areas if you care enough.” In addition to leading one to eventually solve problems, this process can also help start independent thinking without external triggers like “teachers’ initiative questions” or “group debates.”



*Confusing:* Although participants understood critical thinking as a way of thinking, problem-solving and a process, some expressed their struggles and frustrations in efforts to figure out its clear definition. Five Chinese international participants expressed their wish to know its definition or a “guide” clearly because in reality, they were only understanding and learning it through “foggy clouds.” With a clear definition and instructions, these participants would perform and learn better on critical thinking. While none of the domestic participants directly said that they were confused by the meaning of critical thinking, most of them (most of the participants in fact) asked me my understanding of critical thinking in the interview. It may have suggested their doubts and hesitations about expressing their own understandings of critical thinking.

## **CHAPTER 5. DISCUSSION AND IMPLICATIONS**

When concluding a transcendental phenomenological study, Moustakas (1994) recommended phenomenology researchers return to the literature review and compare their findings with previous research, outline the implications of the study for future research, develop a summary of the study in its entirety, and consider possible limitations. The final chapter of this study, therefore, includes the following sections: (1) Discussion of the study findings and how they are related to my research questions and previous literature, (2) Implications for future research and teaching; and (3) Conclusion and possible limitations of the study.

### **Discussion**

The research questions in the present study include one central research question that answers the how and what the participants experienced and perceived critical thinking, and two subquestions that provide additional answers to the central question.

The research questions are as follows:

Central Research Question:

How do Chinese international and domestic junior and senior STEM students perceive and describe critical thinking?

Subquestions:

(1) Do the two groups both believe critical thinking has an important impact on their education and life in general?

(2) What suggestions do the two groups have for their instructors to facilitate their critical thinking comprehension and application?

In this section, I discuss the findings of the present study in relationship to each of the three research questions and to the extant literature examining critical thinking. The central research question examines the overall experience of understanding critical thinking for the specific group of 25 STEM college students (13 Chinese international and 12 domestic STEM junior and senior students) who participated in this study. I extended this examination into the phenomenon of understanding critical thinking among STEM students via two subquestions exploring (1) the significance of critical thinking in their opinions; and (2) suggestions that they have for their instructors to improve their critical thinking.

**Central Research Question: How do Chinese International and Domestic Junior and Senior STEM Students Perceive and Describe Critical Thinking?**

My central research question examined the overall experience of understanding critical thinking for a specific group of 25 junior and senior STEM college students (13 Chinese international and 12 domestic STEM students). My examination uncovered that, essentially, the 25 participants experienced critical thinking mainly as a tool to assist their problem solving and learning in general. The findings conform to some critical thinking aspects of the state, trait, and emergent perspectives (i.e., APA, 1990; Facione, 2000, 2015; Paul, 1990; Siegel, 1988) that I reviewed in Chapter Two. The essence of the experience was derived from the four core textural themes that were uncovered: they experience critical thinking as a way of thinking, problem solving, a process, and also a confusing concept. In the following sections, I discuss each theme in terms of its relationship to the central research question and previous literature.

### **Theme One: Critical Thinking is a Way of Thinking Comprehensively and Logically**

Participants' understanding of critical thinking as a way of thinking comprehensively and logically coincides with some skill aspects of critical thinking in general that I reviewed in Chapter Two. Multiple participants specifically emphasized their understanding of critical thinking as a way of thinking comprehensively and logically: "thinking comprehensively from multiple perspectives/ different perspectives," "thinking dialectically," "thinking logically," and "logic." This finding is also congruent with the disposition aspects from critical thinking experts in the American Philosophical Association (1990), Facione (2000; 2015), Halonen (1995) and Paul (1990; 1994), who all underscored the important aspects of exchanging and embracing with other minds/perspectives in critical thinking, and highlighted how logic and logical thinking can help in reasoning and development of critical thinking skills.

Consistent with the disposition aspects by Garrison (1991), Quitadamo et al. (2008), and Rowe et al. (2015), multiple participants in the present study expressed their understanding of critical thinking as comprehensive thinking to analytically collect different and multiple perspectives, and open their own mind and horizons to embrace others. Through dialogues and interactions with peers (e.g., group discussions and group projects) and professors (e.g., in lectures and during office hours), participants mentioned that their original thoughts and horizons could become more broad and comprehensive. Chad shared, "to broaden the horizons is to say that, not to limit on your own ideas, but to see how others see and think and then look back at your original idea to see if yours is one-sided. This is the core of critical thinking." Connor commented that critical thinking

is to “think from a small point and then expand it to a circle,” and as a result “your knowledge would be expanded and updated.” Participants also acknowledged that everything is possible and knowledge is never absolute, which is echoed in Perry’s (1970) suggestion about undergraduate students most likely not passing the Relativism stage (position 4, 5 and 6) before graduating from college. Cameron commented, “in the world of grey knowledge...there is no absolute thing in this world and so you will realize [that] your understanding of knowledge will be more and more unlimited. So, it is crucial to not conclude something 100% and always use multi angles to consider an issue.”

Some participants understood critical thinking as thinking logically and emphasized the exchangeability from critical thinking to logical thinking. Cynthia interchanged critical thinking with thinking logically or logic in her interview and stressed the importance of thinking logically and logic in her college education. Cynthia said, “CS [Computer Science] itself is a profession that requires you to think logically...if we [CS students] do something that has a bias, then the computer will say: I quit. I mean you want to think logically like a computer.” Courtney commented similarly, “I think critical thinking is a logic of thinking...with stronger logic, you can write argumentative [papers].” Participants understood the important relationship between logic and critical thinking which is partially consistent with skill aspects I discussed in Chapter Two, but meanwhile they overemphasized the relationship and amplified the overlap between logic and critical thinking. Logic benefits critical thinking as a way of examining and evaluating one’s reasoning process and inferences, and determining the strength of an argument (APA, 1990; Durkin, 2008, 2011; Walkner & Finney 1999), but logic is a

different area than critical thinking (McPeck, 2016; Salmon, 1995) and has different specific skills.

Last but not the least, among the 14 of 25 participants who contributed to this theme, nine were Chinese international participants and five were domestic participants (see Table 4). In other words, almost 70% of Chinese international participants and 42% of domestic participants in the study understood critical thinking as a way of thinking comprehensively and logically. This finding from the present study are contrary to the discussion in Chapter Two suggesting that Chinese students may not be skilled in critical thinking (Atkinson, 1997; Hofstede & Bond, 1994; Lee et al., 2014), but in line with the studies of Durkin (2008) and Tian and Low (2011) who suggested that Chinese students may not be familiar with the Western style of critical thinking, rather than not knowing how to think critically. With the ease and comfort of being interviewed in their native language, Chinese international participants shared and contributed their understanding, which captured some important aspects of critical thinking.

### **Theme Two: Critical Thinking is Problem Solving**

Various participants also understood critical thinking as problem solving. This understanding is partially consistent with the literature on teaching critical thinking that was discussed in Chapter Two. Pithers and Soden (2000) mentioned that teaching critical thinking sometimes overlapped with teaching problem solving in classrooms.

Afamasaga-Fuata'I (2005), Paul (1994), Durkin (2008, 2011), and Scollon (1999) stressed the importance of higher order thinking in problem solving and stated that questioning is to the path of knowledge and truth. Questioning is also an important overlapping skill in critical thinking. Courtney said that "critical thinking screams

problem solving” and Anthony commented that critical thinking is “knowing how and why to solve problems” especially “knowing when and how to use your previous knowledge in real life problems.” The real life problems are the ones where “you are given no directions,” Andy said, so critical thinking is knowing to “use all the skills you know to be creative and less rigid, and think outside of the box in order to solve these problems.” When practicing critical thinking, Cody suggested using “questioning,” Anna suggested creativity and being rational, Arthur suggested “analysis and evaluation,” and Amber suggested a deductive reasoning process, “taking basic knowledge and applying it to a deeper level, and expanding it on a wider level.”

While critical thinking is not equivalent to problem solving per se as some participants may have understood in the present study, there is an important relationship between the two. The fact that participants understood critical thinking as problem solving highlights the overlap between critical thinking and problem solving. Problem solving is a means for achieving important goals during which we need to monitor our process continually and switch strategies if necessary (Martinez, 1998). It involves critical thinking but also engages with decision-making and questioning. In other words, high levels of problem solving skills are correlated with critical thinking skills (Sahin & Kumcagiz, 2017), but they are two different areas.

The problems that various participants mentioned in the study are mainly real-life/authentic inquiry related problems—some of which are ill-defined real life problems (e.g., Andy’s “toast bread without a toaster” problem, or Cassandra’s “apartment hunting” problem, or Asher’s “time management” problem), and some of which are research related questions/problems that they have not been taught (e.g., Amber’s

“hormone research project” where she was mostly on her own to find and solve the problem, or Chad’s searching for the solution that was both “cost and geography friendly” for his circuit project design).

Among the 17 out of the 25 participants who contributed to this theme, 12 were from Engineering majors, including five junior and seven senior engineering students. These participants particularly stressed how they were taught that engineering majors were to solve problems and engineers should be experts in problem solving. Anthony commented, “if you do not know how to think critically, essentially solve problems, then you should not be an engineer.” Andy also held a similar opinion and said that after some “weed-out” classes, engineering students should not complain but know how to solve problems even without being given directions. Austin explained how engineering major students should know “how to think rather than what to think.” Among the 17 participants, eight were Chinese international students who showed a similar understanding of critical thinking as the other nine domestic peers. This again supports the study of Durkin (2008) that Chinese international students can learn to think critically in the Western academic standards of critical thinking but may consciously choose not to progress in a certain stage where it would mean abandoning their own cultural norms and values to fit in the Western culture of being “insensitive and unnecessarily offensive” to think critically (p. 7), which often is interpreted as lack of critical thinking in classrooms.

### **Theme Three: Critical thinking is a Process**

Similar as how the two previous themes related to previous literature, this understanding of critical thinking as a process is also only partially consistent with the prior literature. Prior literature on skill aspects stated that critical thinking is an



intellectually disciplined process with a central focus on reason (Mulnix, 2010; Scriven & Paul, 1987). Students must also learn the process of critically thinking just as they learn the process of the scientific method (Scriven & Paul, 1987). This intellectually disciplined reasoning process is not same as thinking in general, but “one of a family of closely related forms of higher order thinking. Others include problem solving, creative thinking and decision making” (Rudd, 2007, p. 48). In the present study, some participants understood critical thinking as a process, during which you especially learn from your mistakes and develop your thinking in general. However, they neither specified what skills you would need in this critical thinking process nor differentiated this process from a general thinking process.

Andy said it was “a trial and error process from point A to point B” and Alec commented similarly that through the process you would be “modifying your approach and trying not to fail again.” This process of thinking critically also allows one to grow as an independent thinker; Amber said, “You can do it [thinking critically] on your own once the teacher initiates it.” Arthur and Asher specifically accredited the mentality or mindset for this process of thinking critically. Arthur believed that it would become easy “once you become habituated to it” and Asher commented the mental process “combines skills with your background knowledge.” Through this process of thinking critically, one not only becomes more cautious and critical when accepting others’ opinions but also is more likely to engage the process—thinking critically—in areas other than the usual academic disciplines. For example, Casey believed that one would not “believe all what others say,” and Caroline thought this mentality can be transferred to other areas if one

cares enough, which is similar to what Amanda hoped—continuing this mental process in other areas of her life after graduation.

Among the 10 of 25 participants who contributed to this understanding, seven were domestic participants and three were Chinese international participants. While this phenomenology study is interpreting this particular phenomenon within this context rather than generalizing the results to a larger population, it was surprising to find that Chinese international participants mentioned or emphasized the role of mistakes and errors in the process of thinking critically less often than domestic participants did in the interviews. Future studies should further examine how Chinese international students think of mistakes and errors in their critical thinking development and learning.

#### **Theme Four: Critical Thinking is Confusing**

Lack of clarity about the nature and evaluation of critical thinking has caused it to be thought of as problem-solving (Kennedy, Fisher & Ennis, 1991), which consequently leads the “teaching approaches to problem-solving that are unlikely to develop more widely transferable generalizable critical thinking abilities and dispositions” (Pithers & Soden, 2000, p. 239). Most of the participants asked me what my understanding of critical thinking was at beginning of the interview. After I told them that only their understanding mattered in the interviews, five Chinese international participants directly expressed their confusion towards critical thinking later in their own respective interviews, while domestic participants did not express the same feeling. This finding of students being confused about this concept is well documented in previous literature on teaching critical thinking. Literature showed that teachers lacked training, resources, and time to implement critical thinking in their classrooms (Paul, Elder, & Bartell, 1997;

Synder & Synder, 2008). As a result students were rarely systematically taught or trained in the skills to be analytical, fair, and open-minded in their pursuit of knowledge, which are important to understand and apply critical thinking to their disciplinary studies (Synder & Synder, 2008). Moreover, without proper teaching and training, students hardly ever acquired these skills on their own (Rippen, Booth, Bowie, & Jordan, 2002). In other words, although students may understand that critical thinking is important, they do not know how to think critically. For example, Colin hoped to know critical thinking more from his future experiences and projects. Chad, Cameron and Casey all shared a similar statement, saying that they think they know how to use it [critical thinking], but do not know its clear definition. Chad mainly used “dialectical thinking” as critical thinking; Cameron mainly used thinking comprehensively and choosing between two polarized positions as critical thinking; and Casey mainly used problem solving (as a tool to shield you from false information and credulity) as critical thinking. With more clear and detailed instructions on thinking critically in classrooms, students may understand what critical thinking is and how to more efficiently use critical thinking. Like what Chad and Cassandra commented, “Knowing the clear definition would help me better to think critically.”

**Subquestion 1: Do the Two Groups both Believe Critical Thinking has an Important Impact on Their Education and Life in General?**

This research subquestion revealed that both groups of participants considered critical thinking to be important for their education and career but saw it as less important for their everyday life. This finding from the present study resonates with the extant literature on critical thinking being considered as an essential goal in education and an

important goal of curricula (Dewey, 1916, 1933; APA, 1990; Marshall & Tucker, 1992; MacKnight, 2000; Kasten, 2012). All of the 25 participants said they felt critical thinking was very important for their education. For example, Anna said, “my whole major is critical thinking so it is very important for my education;” Cody commented that critical thinking is important for his education for it would allow him to “understand the knowledge and concept better” in his engineering classes; Carter said critical thinking helps him learn and apply knowledge better; Caroline mentioned critical thinking was very important for her education because “it allows you to have your own thoughts and values, which is crucial in your studies;” Allen emphasized its importance in his education because “the field is rapidly changing and you have to think critically to understand the essence of some questions/problems/situation.” Similarly, all participants thought critical thinking was important for their careers. Some emphasized its usefulness in solving new problems in their future career, while others thought it was important in maintaining relationships with colleagues in their future career. For example, Andrea, Courtney and Caroline all emphasized how critical thinking would help them become more confident in solving new job-related problems especially problems that “you would never encounter in school,” said Caroline. Both Alec and Colin commented that critical thinking helps their interpersonal relationships with colleagues because “you will know how can you fix the relationship with this person and it will make your office work and work life a lot easier,” said Alec.

Most participants acknowledged that critical thinking may be beneficial for making their everyday life easier but they did not think they would be willing to use critical thinking, as they would do for their education and career. This is consistent with

the literature on critical thinking dispositions and critical thinking transferability (Halpern, 1998; Housen, 2002; Sears & Parsons, 1991). In the present study, the participants did recognize possible benefits of using the critical thinking in school and their everyday life. For example, Andy said he thought critically and used a microwave to toast bread instead of buying a new toaster. Even though it may involve more problem solving skills, he did see critical thinking as a helpful tool in everyday life. Arthur and Cynthia both said they thought critically about their spending habits, which had saved them from unnecessary spending (e.g., buying too many coffees from coffee shops in Arthur's situation, and buying impractical pairs of shoes in Cynthia's situation). Cassandra also thought critical thinking might be helpful in her future apartment hunting. However, participants were not enthusiastically willing to think critically for everyday life situations. They tended to avoid it because it required a lot conscious exertion of mental effort, which was "tiring," said Cameron. Anna also said, "Critical thinking is definitely tiring and so people don't like to think and would rather watch TV instead." Cameron stated that the early stages of thinking critically in a new situation for a new problem can be very tiring and intimidating. It demands your brainpower to continue doing it, but with "practice and patience" it would become easier, said Chad. To sum up for this subquestion, participants recognized the critical thinking that they learned and practiced in school could be transferred and used in everyday life, but they would rather not to do so as formally and intensively as for their education and career.

**Subquestion 2: What Suggestions do the Two Groups have for their Instructors to Facilitate their Critical Thinking Comprehension and Application?**

This research subquestion uncovered the following theme: participants thought their critical thinking could be enhanced through more hands-on and real-life research projects, dialogues and interactions with the professors who not only model how they think critically but also encourage questionings from their students, as well as meaningful small group discussions and work. This finding is congruent with previous literature on strategies to teach critical thinking (Duron et al., 2006; Pithers & Soden, 2000) and foster students' critical thinking in STEM disciplines (Gottesman & Hoskins, 2013; Lord, 2001; Quitadamo, Brahler & Crouch, 2009). In the present study, for example, Amber said her mini-research experience helped her analytical thinking, as did the many "why" questions her professors had asked during the research process; Amber thought both of these helped initiating and improving her critical thinking. Cynthia and Austin said the real-world research projects in homework and real world examples in lectures helped them thinking logically and critically. Compared to the classes that mostly asked her to memorize the content from PowerPoint slides, Amanda appreciated much more the professors who showed the class their critical thinking process (e.g., how they solve a new problem or answer a question), and asked the class many engaging questions. She said the process of seeing her professors modeling the critical thinking process to solve the specific discipline related problems was helpful when she did it herself. In addition to research projects and engaging professors, Anthony also felt small group work helped his critical thinking and understanding knowledge in general, because through the process of debating with his peers for better solutions, not only a friendship was formed but also

different perspectives and knowledge were shared and acknowledged. Anna mentioned similar comments about group work, but she thought some group members were not as engaged and committed as others, which may have reduced her motivation to think critically.

### **Implications for Research and Teaching**

Previous studies examining critical thinking predominantly consisted of quantitative measurement studies (e.g., investigating students' performance on critical thinking skills tests and/or dispositions tests); in contrast to these studies, I employed a qualitative research methodology of transcendental phenomenology to delve deeper into the students' own experiences and understanding of critical thinking, and its implications for researchers and educators.

In this section, I identify and discuss areas for further research: (a) a mixed-methods study to first explicitly introduce the nature of critical thinking in classrooms, and then examine and compare students' critical thinking performance and understanding; and (b) more research studies on implementing the hands-on research teaching strategies. I also address broad implications for teaching and improving students' critical thinking.

### **Research Implications**

In my literature review and findings from the present study I found that students misunderstood critical thinking and confused it with dialectical thinking, problem solving, decision-making, and good learning in general. Future mixed-methods research could concurrently utilize qualitative methods and the Critical-thinking Assessment Test (CAT; Center for Assessment and Improvement of Learning at Tennessee Technological

University, 2010) to examine and compare the relationship between students' performance on CAT and their verbal understanding of critical thinking through interviews and focus groups. The Critical-thinking Assessment Test is a measurement instrument that's developed to

...access a broad range of skills that faculty across the country feel are important components of critical thinking and real world problem solving...Questions derived from real world situations with most questions requiring short answer essay responses...[CAT also] engages faculty in the assessment and improvement of student critical thinking skills and connects faculty to a teaching community (Center for Assessment and Improvement of Learning at Tennessee Technological University, 2010).

In their study, Quitadamo et al. (2009) suggested that “in order to ensure fairness and consistency for all students, institutions of higher education should consider explicitly teaching critical thinking skills rather than assuming all students process them a priori” (p. 37). In a mixed-methods study, therefore, a researcher could explicitly introduce to the experimental group to the nature of critical thinking including the skills approaches, dispositions approaches and the emergent approaches (e.g., Perry's scheme), and then examine and compare the results from the two groups (i.e., experimental group and control group) regarding their CAT performance and interviews/focus groups. Perry (1970) advised that college students' cognitive and intellectual development progress is in conformity with their age, the years they spent in college, and their discipline of study. Therefore, participants in the mixed-methods study could be delimited to undergraduate students in the same year and from the same or similar majors. The process may help to



further identify if clear instruction on the nature of critical thinking has positive impacts on participants' performance and understanding of critical thinking, and any differences between the experimental group and control group on their performance and understanding.

In addition, future research studies should investigate students' critical thinking and learning gains through implementing hands on real world research projects in introductory course curricula (e.g., general education courses). The present research findings showed that participants valued hands-on experiences from their research studies, homework, and projects regarding their understanding of critical thinking. Literature has supported the importance and benefits of research experience in STEM teaching and learning (Gottesman & Hoskins, 2013; Lord, 2001; Quitadamo et al., 2009). Therefore, it is necessary to further investigate the importance of real world research experiences in students' critical thinking and learning.

### **Teaching Implications**

The present study has broad pedagogical implications for STEM educators, particularly for those who teach introductory STEM courses. First, participants suggested that educators could add more authentic hands-on components into their curricula to foster critical thinking. This teaching suggestion is consistent with previous literature. For example, Gasper and Gardner's (2013) study showed a significant increase in students' level of critical thinking skills after engaging students with authentic research projects in an introductory biology lab course. Rowe et al.'s (2015) study also showed students' improvement in critical thinking after engaging them more with research projects. In introductory lectures, educators can also include more real-world examples and ask

students to read and analyze authentic research papers before assigning them mini-research projects as homework (Rowe et al., 2015; Tsui, 2002). Second, participants suggested that educators should be more aware of the importance of their engaging interactions with students in students' learning. This suggestion is also consistent with previous literature on teaching and improving students' critical thinking. Glaser (1984), Nunn (1996) and Tsui (2002) suggested that educators' feedback, availability (e.g., office hours) and guiding questions in classes are powerful tools for initiating and teaching students' critical thinking and learning in general. Third, participants suggested that educators should continue using small group, especially peer-led, group projects as an effective strategy to enhance students' learning and critical thinking. This suggestion is consistent with the studies conducted by Quitadamo et al. (2009) and Rowe et al. (2015) who suggested the interactive inquiry and discussions in groups were important and necessary for learners to develop critical thinking and knowledge in general.

### **Limitations**

There are two major limitations of the study. The first limitation is that I, as the researcher, translated the Chinese international students' interview transcripts. As a native Chinese student who speaks English fluently, I did not seek out additional triangulations from other Chinese-speaking researchers on my translations. I did use online Google Translate as a supportive translation mechanism when I was not sure about my translations. For example, when Colin said that he understood critical thinking as 辩证法看问题 (*bian zheng fa kan wen ti*), I used Google Translation and found its translation—*looking at the problems in dialectics*—correctly captured what he meant in

Chinese. In the future studies, however, additional triangulation from Chinese-speaking researchers would make a stronger contribution to translation accuracy.

The second limitation is the predominance of engineering participants. Seventeen out of 25 participants were from the field of engineering. Most of the engineering participants mentioned that they were told engineers should be able to solve problems, which I found was the mentality when they shared their understanding and experience of critical thinking within their discipline. While “problem solving” maybe indeed a popular interpretation of critical thinking, the fact that majority of participants in this study were from engineering field is not representative of the diversity of STEM fields. As a result, engineering participants might have been over emphasized and represented in the interpretation of “problem solving” in all participants’ experiences. In the future studies, therefore, having a relatively even distribution of participants from different majors in STEM would reflect more fair policy implications regarding curriculum changes and practices. “In general, if ‘we let a thousand flowers bloom’ in qualitative research, then the body of research evidence that reflects the diversity of the population will, for the most part, develop” (Allmark, 2004, p. 188).

### **Conclusion**

Critical thinking is an essential goal of higher education. The understanding of critical thinking is clouded by its complex nature and difficulties in achieving it in teaching and learning practices. Supported by extant literature, the participants’ experiences and understanding analyzed in this study revealed that the confusing nature of critical thinking affects students’ understanding and application to different degrees. Several participants in the present study showed their vague understanding and

application of critical thinking. They understood it mainly as a process to solve problems during which multiple perspectives should be considered comprehensively and logic should be engaged more often. Although they all thought critical thinking was important for their education and career, the lack of clarity on its nature in classrooms also confused them. In order to assist their ability to think critically in different situations, participating students asked for more research experience especially in their introductory courses where memorization was still the main emphasis, more dialogues with their professors so that they can imitate thinking critically process when they do it on their own, as well as more meaningful group work with their peers. While the findings of the study are consistent with the literature, it was still surprising to see that students were assumed to understand critical thinking as a priori (Quitadamo et al., 2009). In the following sections, I first provide a concluding reflexivity statement describing on how this study has impacted me, and then a summary of the study chapter by chapter.

### **Reflexivity**

Completing this transcendental phenomenological study on understanding students' critical thinking perceptions and experience was both a challenge and a learning process for me. Although I self identify as a qualitative researcher and have been trained to reflect inwardly and outwardly carefully when doing a qualitative study, the amount of self-reflection and self-dialogue required for this study was paramount. Moustakas (1994) encouraged transcendental phenomenological researchers to engage epoche as much as they can in the process of carrying out the study. Because I have both intellectually and emotionally invested in this study, the suggestion was a constant reminder for me "to stay away from" (Moustakas, 1994, p. 85) my own biases and judgments, and try my best to

get my interpretations in line with the participants' voice as much as I can. I believe "the energy, attention, and work involved in reflection and self-dialogue" (Moustakas, 1994, p. 90) was rewarding and significantly reduced my biases.

Moreover, before I carried out the study and based on my own experience with critical thinking, I was inclined to agree with the interpretations (Ip et al., 2000; Tiwari et al., 2003) that implied Chinese students may have poor critical thinking. After completing the study, however, the two groups of participants showed similar (mis)understandings of critical thinking. Both groups showed similar intellectual development, specifically critical thinking development, which is consistent with Perry's (1970) suggestion—most colleges and universities unfortunately do not get their undergraduate college students pass the relativism stage. That is, in the relativism stage, although students start to accept knowledge as relative in our world and have open-mindedness and flexibility to some degree, they are neither ready to commit to explore and practice critical thinking in their personal life nor realize this commitment is an ongoing, unfolding, evolving activity. As a result of this study, my understanding of critical thinking has become more comprehensive. Critical thinking, in my opinion, means a process of questioning the foundation or rationale of a given statement or using certain skills (i.e., critical thinking core skills) and engaging specific dispositions (i.e., critical thinking dispositions).

### **Summary**

In Chapter One, I explained how the overall number of international students enrolled in U.S. universities and colleges is increasing every year, and how, in particular, academic and cultural adjustment issues face Chinese international students on U.S.

campuses. I focused on explaining the definition of critical thinking including skills perspectives, dispositions perspectives and cognitive development perspectives, and how the definition of critical thinking may differ in different cultures and native languages. I discussed briefly about how previous literature measured and evaluated Chinese students' performance in critical thinking tests (e.g., California Critical Thinking Skills Tests, California Critical Thinking Disposition Inventory) compared with their Western peers. I then introduced the problem statement of this study—to qualitatively understand students' own experience and perceptions of critical thinking. Instead of implementing a measurement test to a larger population, I proposed that, through the voices of a smaller group of students, their own experiences and perceptions of critical thinking would be highlighted. At the end of the Chapter One, I also discussed the significance of the study to help both international students, including Chinese international students, and domestic students succeed in college.

In Chapter Two, I carefully reviewed the relevant literature on critical thinking and researched conceptual perspectives of critical thinking. I discussed in detail the three approaches on explaining the nature of critical thinking—skills (state), dispositions/habits (trait) and Perry's Scheme and the Reflective Judgment Model approaches (emergent). I also addressed the importance of critical thinking in the field of STEM learning, and how languages and cultures impact students' critical thinking including second language learners like Chinese international students. I focused on utilizing the skills, dispositions and Perry's Scheme approaches in understanding critical thinking in my study.

In Chapter Three, I examined and explained the transcendental phenomenology method. I reviewed the key points of this method and explained the rationale of using it

in my study. I also explained how my positionality might influence the study and the participants and the procedures of data collection through 25 in-depth, one-on-one interviews with the participants. I described the data analysis procedure that Moustakas (1994) recommended in transcendental phenomenological research: epoche, horizontalizing, meaning units/themes, textural and structural descriptions, and the essence of the experience. I also shared how I would assure trustworthiness in my study.

Chapter Four illuminated my research findings; I discovered that the 25 participants understood and experienced critical thinking mainly as a tool to help their learning and grades in general. This essence of the experience from the participants was derived from the four core textural themes: they experience critical thinking as a way of thinking, an aid for problem solving, a process, but also a confusing concept. And, in the final chapter of my dissertation, I discussed how the findings related to my research questions and previous literature, what future studies may be developed and what teaching strategies can be emphasized to support students' development of critical thinking.

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## APPENDIX A. IRB APPROVAL

IOWA STATE UNIVERSITY  
OF SCIENCE AND TECHNOLOGY

Institutional Review Board  
Office for Responsible Research  
Vice President for Research  
2420 Lincoln Way, Suite 202  
Ames, Iowa 50014  
515 294-4566

Date: 8/29/2017

To: Lu Yan  
3406 Orion Dr, Unit 102  
Ames, IA 50010

CC: Dr. Anne Foegen  
N162D Lagomarcino Hall  
Dr. Linda Serra Hagedorn  
E262 Lagomarcino Hall

From: Office for Responsible Research

Title: Understanding Critical Thinking in American Higher Education: From Chinese International and Domestic STEM Students' Perspectives

IRB ID: 17-394

Study Review Date: 8/29/2017

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- You do not need to submit an application for annual continuing review.
- You must carry out the research as described in the IRB application. Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. Only the IRB or designees may make the determination of exemption, even if you conduct a study in the future that is exactly like this study.

Please be aware that approval from other entities may also be needed. For example, access to data from private records (e.g. student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. An IRB determination of exemption in no way implies or guarantees that permission from these other

entities will be granted.

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or [IRB@iastate.edu](mailto:IRB@iastate.edu).

**APPENDIX B. RECRUITMENT EMAIL**

Dear STEM Junior and Senior Students,

I am a researcher from School of Education at ISU and am currently conducting my dissertation to gain understanding of how STEM junior and senior students perceive critical thinking.

If you are a **Chinese international STEM junior or senior student OR a domestic STEM junior or senior student**, please consider to participate in a one-on-one interview with me. The interview will be about 60 to 90 minutes long and conducted in a semi-private room on campus.

During the interview, you may skip any questions you do not feel comfortable answering. Your individual responses will be kept in strict confidence. Your responses are anonymous and will be used only for research purposes.

You are being invited to participate in this study because you are a STEM junior or senior student attending Iowa State University. If you are under 18 years old or not a STEM junior or senior student, please ignore the email.

If you agree to participate in the interview, you will receive a \$20 gift cards to use at Starbucks as a small token of my appreciation.

If you would like to participate in the interview, please contact me at [lyan@iastate.edu](mailto:lyan@iastate.edu) or 515-294-4640.

Your time and consideration are deeply appreciated.

Sincerely,  
Lu Yan,  
Ph.D. Candidate,  
School of Education,  
323 Carver Hall,  
Iowa State University,  
[lyan@iastate.edu](mailto:lyan@iastate.edu)

**APPENDIX C. LIST OF STEM MAJORS IN THIS INSTITUTION**

- Aerospace Engineering
- Agricultural Biochemistry
- Agricultural & Biosystems Engineering
- Agricultural Systems Technology
- Agriculture undeclared
- Agronomy
- Animal Ecology
- Animal Science
- Athletic Training/Pre-Athletic Training
- Biochemistry
- Bioinformatics and Computational Biology
- Biological & Pre-Medical Illustration
- Biological Systems Engineering
- Biology
- Biophysics
- Chemical & Biological Engineering
- Chemistry
- Civil Engineering
- Computer Engineering
- Computer Science/Pre-Computer Science
- Construction Engineering
- Culinary Science

- Dairy Science
- Diet and Exercise/Pre Diet and Exercise
- Dietetics/Pre-Dietetics
- Earth Science
- Electrical Engineering
- Engineering undeclared
- Environmental Science
- Food Science
- Forestry
- General Pre-veterinary Medicine
- Genetics
- Geology
- Global Resource Systems
- Horticulture
- Industrial Engineering
- Industrial Technology
- Insect Science
- Kinesiology and Health
- Materials Science and Engineering
- Mathematics
- Mechanical Engineering
- Meteorology
- Microbiology

- Natural Resource Ecology and Management
- Nutritional Science
- Physics
- Plant Pathology
- Pre-Professional Health Programs
- Preparation for Human Medicine
- Software Engineering
- Statistics